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FISHES OF THE GULF OF MAINE

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INTRODUCTION

In the summer of 1912 the Bureau of Fisheries, with the cooperation of the Museum of Comparative Zoology of Harvard University, undertook an oceanographic and biological survey of the Gulf of Maine, with special reference to its fishes and floating plants and animals (plankton), its physical and chemical state, and the circulation of its waters. Subsequent cruises were made on the fisheries schooner *Grampus* during the summers and autumns of 1913, 1914, 1915, and 1916, and during the winters and springs of 1913 and 1915. The work was interrupted by the war, but was resumed with a cruise of the fisheries steamer *Albatross* in the late winter and spring of 1920 and continued by the fisheries steamer *Halcyon* during the winter and spring of 1920–21 and the summers of 1921 and 1922. Several reports on special phases of the survey have been published, but not until 1920 did the body of data warrant undertaking a general account of the fish fauna, general biology, and oceanography of the Gulf, of which the present memoir is the first part.

In the division of labor the preparation of the section on the fishes was assigned to my coworker, W. W. Welsh, who had given special attention to this phase of the work throughout all the years of the survey, both on the regular oceanographic cruises and on many trips on commercial fishing vessels, in the course of which he

had gathered a large body of original observations on the growth, reproduction, diet, and other phases of the lives of many of the more important species. The report was far advanced when interrupted by his untimely death, and so much of the material had been collected that, at the request of the Bureau of Fisheries, I have undertaken to carry it to publication along the lines originally laid down, though I am unable to give it the value it would have possessed had Mr. Welsh been able to finish it.

SCOPE OF THE WORK

Our aim has been to prepare a handbook for the ready identification of the fishes occurring in the Gulf of Maine, and to present a concise statement of what is known of the distribution, relative abundance, and the more significant facts in the life history of each. The descriptions have been made as little technical as is compatible with scientific accuracy, and are chiefly limited to such external features as may suffice for identification in the field. As a further aid to identification, keys to all species have been provided. In every case the sizes of larval fish or eggs have been given in millimeters (1 inch equals 25.4 millimeters), but these can be easily converted into inches or parts of an inch. We have followed Garman (1913) in the nomenclature of the sharks, skates, and rays, and Jordan and Evermann (1896–1900) for all the others, except as noted. For each species we have given page references to these authors, where the reader, if interested, may find more detailed descriptions and synonymies. Most of the illustrations have been borrowed from earlier publications, but a few are original. Rules given under illustrations represent a length of 1 inch.

AREA COVERED

The term "Gulf of Maine" covers the oceanic bight from Nantucket and Cape Cod on the west to Cape Sable on the east, thus including the shore lines of northern Massachusetts, New Hampshire, Maine, and parts of New Brunswick and Nova Scotia. The eastern and western boundaries adopted in this paper are 65° and 70° west longitude, respectively. Southern species, recorded but once from Nantucket and which have no real status in the Gulf of Maine except as accidental stragglers, have been relegated to footnotes. The Gulf of Maine has a natural seaward rim formed by Nantucket Shoals, Georges Bank, and Browns Bank. We have chosen the 150-fathom contour as the arbitrary offshore boundary because this will include all the species likely to be caught by commercial fishermen and will exclude almost the entire category of deep-sea fishes so numerous in the basin of the open Atlantic but not constituents of the fauna of the Gulf of Maine.

The general geography of this area will be the subject of another report, but it may not be amiss to point out here that the temperature of the Gulf and its fauna as a whole are boreal, its southern and western boundaries being the northern limit of common occurrence of many southern species of fishes and invertebrates.

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SOURCES OF INFORMATION

The literature dealing with the fishes of the Gulf of Maine begins with the earliest descriptions of New England, for the fishery possibilities of the Gulf so impressed the early voyagers, even prior to the first settlement, that almost all accounts of their travels contain first-hand observations on the local abundance of fish of one species or another. Capt. John Smith (1616), for instance, commented on the abundance of sturgeon, cod, hake, haddock, cole (the American pollock), cusk, sharks, mackerel, herring, cunners, eels, salmon, and bass in 1616, while Wood (1634), in his "New England's Prospect," gives much interesting information, some of which is quoted hereafter. It was not until the early part of the nineteenth century that the sea fishes of northern New England and of the Maritime Provinces began to attract scientific attention, but since then the local faunal lists for that region have become numerous. The following, in chronological order, are the most important of these:

1850.—"Report on the sea and river fisheries of New Brunswick, within the Gulf of St. Lawrence and Bay of Chaleur," by M. H. Perley. 137 pp., 1850. Fredericton.

1853–1867.—"A history of the fishes of Massachusetts," by David Humphreys Storer. Memoirs, American Academy of Arts and Sciences, New Series, Vol. V, pp. 49–92, 122–168, and 257–296; Vol. VI, pp. 309–372; Vol. VIII, pp. 389–439; Vol. IX, pp. 217–256, 39 pls. (Also in book form with supplement.) Cambridge and Boston.

1879.—"A list of the fishes of Essex County, including those of Massachusetts Bay, according to the latest results of the work of the U. S. Fish Commission," by George Brown Goode and Tarleton H. Bean. Bulletin, Essex Institute, Vol. XI, No. 1, pp. 1–38. Salem.

1884.—"Natural history of useful aquatic animals," by George Brown Goode and associates. Section I, The Fisheries and Fishery Industries of the United States, published jointly by the United States Fish Commission and the United States Bureau of the Census. Washington.

1908.—"Fauna of New England. 8. List of the Pisces," by William C. Kendall. Occasional Papers, Boston Society of Natural History, Vol. VII, No. 8, April, 1908, pp. 1–152. Boston.

1914.—"An annotated catalogue of the fishes of Maine," by William C. Kendall. Proceedings, Portland Society of Natural History, Vol. III, 1914, Part 1, pp. 1–198. Portland.

1922.—"The fishes of the Bay of Fundy," by A. G. Huntsman. Contributions to Canadian Biology, 1921 (1922), No. 3, pp. 1–24. Ottawa.

Either at first hand or by reference to the original sources these faunal lists contain all the published locality records of the rarer species, while the last two, with a paper by Gill (1905b), give complete ichthyological bibliographies respectively for the coasts of Maine, New Brunswick and Nova Scotia, and Massachusetts. A similar list of the captures of deep-water forms along the outer part of the Continental Shelf is contained in Goode and Bean's "Oceanic Ichthyology" (1896).

The most pertinent extralimital lists are Smith's (1898) and Sumner, Osburn, and Cole's (1913) lists of Woods Hole fishes for the waters immediately to the west, and Halket's (1913) check list of the fishes of Canada for those to the east and north of the Gulf of Maine. With these readily available we have not thought it worth while to burden the present paper with the authorities for localities except in the more interesting cases. To save constant repetition we state here that almost all of the information as to the Bay of Fundy given hereafter is drawn either from Huntsman's paper or from his unpublished notes. Much information as to local

distribution and relative abundance has been gleaned from the fishery statistics published by the United States Bureau of Fisheries, the Dominion of Canada, and the Commonwealth of Massachusetts.

The literature dealing with the lives and habits of fishes occurring in the Gulf of Maine is very extensive, for most of the important commercial species, and many of the others, are common to both sides of the North Atlantic and have come within the scope of the intensive studies carried out of late years by European zoologists in conjunction with the International Committee for the Exploration of the Sea, while considerable attention has been devoted to them by American ichthyologists, also (published for the most part by the United States Bureau of Fisheries). The many scattered accounts of eggs and larvæ of northern fishes have been collected by Ehrenbaum [1] in his general summary of their developmental stages, a compilation the utility of which can hardly be overrated.

Among the other general European manuals, Day's "Fishes of Great Britain and Ireland" [2] and Smitt's "Scandinavian Fishes" [3] are especially helpful. We have also had access to a great amount of unpublished material in the files of the Bureau of Fisheries, especially instructive being the schedules turned in by observers who accompanied certain otter trawlers during 1913, and the observations of Vinal Edwards on the diet of fishes at Woods Hole. The superintendents of the New England hatcheries have supplied much valuable information, as noted in the appropriate connections. Dr. A. G. Huntsman has, with great kindness, contributed his unpublished notes on the fishes of the Bay of Fundy and Gulf of St. Lawrence, allowing us to quote freely from them, while Prof. J. P. McMurrich has permitted the use of his unpublished plankton records. W. F. Clapp, formerly of the Museum of Comparative Zoology at Harvard University, has contributed many interesting notes gleaned during his experience as a fisherman before his entrance into the scientific field. Harry Piers, of the Provincial Museum of Halifax, has supplied interesting notes on the occurrence of the blue shark.

We owe a debt of gratitude, also, to Dr. Samuel Garman, who has ever been ready with assistance, and to W. C. Adams, director of the division of fisheries and game of the State of Massachusetts. Finally, we wish to express our thanks to the many commercial fishermen who have unfailingly met our inquiries in the most cordial way and who supplied Mr. Welsh with a vast amount of first-hand information on the habits, distribution, and abundance of the commercial fishes, which could be had from no other source. Without their help the preparation of this handbook would have been impossible.

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[1] Eier und Larven von Fischen, by E. Ehrenbaum. Nordisches Plankton, Vol. I, 1905–1909 (1911), 413 pp., 148 figs. Kiel und Leipzig. (Appeared in two parts as Lief. 4, 1905, and Lief. 10, 1909.)

[2] The fishes of Great Britain and Ireland, by F. Day. Text and atlas, 1880. London and Edinborough.

[3] A history of Scandinavian fishes, by B. Fries, C. V. Ekstrom, and C. Sundervall. Second edition revised and completed by F. A. Smitt, 1892, 1,240 pp., 53 pls. Stockholm.

USE OF THE KEYS

The various fins and other structures mentioned in the keys are named in the accompanying outline of a haddock, and the simplest way to explain the use of the keys is to use that species as an example, running it down with the outline at hand for reference.

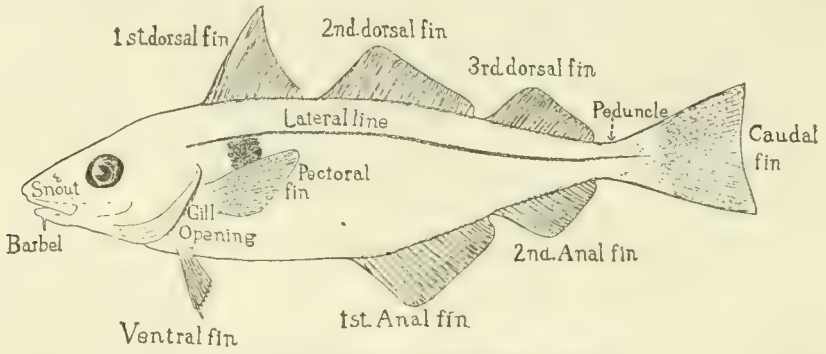

FIG. 1.—Diagram of a haddock, explaining terms used in key

Turning to section 1, Key A (p. 11), the fish in question evidently fits the second alternative, for it has bony jaws and pectoral fins and is not formed like an eel, which refers us to section 3. As our fish does not have a tubular snout this leads us to section 4, and this in turn to section 5, since neither jaw is greatly prolonged. There being only one gill opening on each side we go from section 5 to section 7, and from section 7 to section 8, for there is a distinct tail. Since the fish has no sucking plate on the top of the head this leads to section 11, and this in turn to section 12 because the tail fin is nearly symmetrical in outline. Since the fish is not clothed in an armor of bony plates we are referred by the second alternative of section 12 to section 13. In our specimen the anal fin is clearly separated from the caudal, and section 13 therefore refers us to section 14. As all the fins are supported by rays we must go on to section 15, and from there to section 18 as there are no fleshy flaps or tags on the sides of the head.[4] Our fish does not lie flat on one side (that is, it is a round, not a flat fish) and therefore it fits the second alternative under section 18, which refers it to section 19, and as there is more than one separate dorsal fin, this leads to Key F, page 13.

As we have already determined, all the dorsal fins have soft rays, and since there are no spines in any of the fins (a fact easily determined by feeling them), this sends us to the key to the cod and silver hake families (p. 385). Turning to the first section of the latter we find that the fish fits the first alternative (3 dorsal fins and 2 anals), which refers it to section 2, and here the black lateral line and the dark blotch on each shoulder name it a haddock.

Any other Gulf of Maine species is to be named in the same way, starting with section 1, Key A, and following through the appropriate alternatives as they refer it from section to section.

[4] There is a barbel on the chin but this is very different in appearance from the skin flaps around the jaws characteristic of the few species that fall under the first alternative.

KEY TO GULF OF MAINE FISHES

Key A

1. Mouth soft with no bony jaws; form eel-like; no pectoral fins ---- 2
   Mouth has bony jaws; pectoral fins present if form is eel-like ---- 3
2. Two separate fins on back; no barbels on snout ---- Lamprey, p. 18
   Only one fin on back; barbels on snout ---- Hag, p. 16
3. Bones of head fused in a tubular snout, with mouth at tip ---- Key B, p. 12
   No tubular snout ---- 4
4. One or both jaws greatly prolonged as a bony sword or bill ---- Key C, p. 12
   Neither jaw greatly prolonged ---- 5
5. Five or more pairs of large gill openings (on sides of neck in sharks; on lower surface in skates) ---- 6
   Only one external gill opening, large or small, on each side ---- 7
6. General form cylindrical ---- Sharks, key, p. 23
   General form flat and disklike, with long whiplike tail ---- Skates and rays, key, p. 57
7. Body abruptly square-cut close behind the very high dorsal and anal fins ---- Sunfish, p. 301
   Body with distinct tail ---- 8
8. Large sucking plate or disk, either on the top of the head or on the chest ---- 9
   No sucking disk or plate ---- 11
9. Sucking plate on top of head ---- Remora family key, p. 349
   Sucking disk on chest ---- 10
10. General form like a tadpole; anal fin originates about as far back as the tip of the pectoral ---- Sea snail family key, p. 340
    General form not like a tadpole, but high arched with longitudinal ridges; anal fin originates far behind tip of pectoral ---- Lumpfish family key, p. 334
11. Tail like a shark, i. e., with upper lobe much longer than lower ---- Sturgeon, p. 75
    Tail nearly symmetrical ---- 12
12. Whole head and body clothed in continuous armor of bony plates ---- Alligator fish, p. 333
    If bony plates are present they do not form a continuous armor over head and body ---- 13
13. No clear separation between anal and caudal fins, which together form one continuous fin (anal portion may be either long or short) ---- Key D, p. 12
    Anal and caudal fins separated by a deep notch if not by a space ---- 14
14. There is a fleshy (adipose) fin with neither spines nor rays behind the rayed dorsal fin ---- Key E, p. 13
    A fleshy flap[5] in front of dorsal fin ---- Tilefish, p. 352
    All dorsal fins supported by rays or spines, which can be felt if not seen; without fleshy lobes or adipose fins either in front of or behind them ---- 15
15. Head fringed with fleshy tags or flaps; much broader than body ---- 16
    Head not fringed with fleshy flaps ---- 18
16. Lower jaw projects far beyond upper, exposing very large conical teeth even when mouth is closed; two long isolated spines on top of head in front of eyes ---- Goosefish, p. 524
    Lower jaw does not project noticeably beyond upper; teeth small; no long isolated spines in front of eyes ---- 17
17. First (spiny) dorsal fin longer than second (soft rayed); neither is fleshy ---- Sea raven, p. 330
    First (spiny) dorsal fin much shorter than second (soft rayed); both thick and fleshy ---- Toadfish, p. 357

[5] Although this flap suggests the adipose fin of a salmon in appearance, it is not actually an analogous structure, but simply a lobe of skin.

Key A—Continued

18. Fishes which lie flat on one side, with both eyes on the other side, the upper side dark, the lower pale ..... Flatfish tribe key, p. 472
Not lying flat on one side 19
19. Only one well-developed dorsal fin (this, however, may be preceded by isolated spines or rays) 20
Two or more separate and well-developed dorsal fins ..... Key F, p. 13
20. Top of snout with several barbels or beards ..... Rocklings (cod family in part) key, p. 385
No barbels or beard on top of snout 21
21. Jaws with very large canine tusks which project even when the mouth is closed ..... Wolffish family key, p. 370
No large canine tusks 22
22. Dorsal fin soft-rayed, except that there may be a short spine at its forward margin ..... Key G, p. 14
At least forward one-third of dorsal fin, if not whole length, spiny ..... Key H, p. 15

Key B

Fishes with tubular snouts (from No. 3, p. 11).

1. Head horselike; trunk deep, narrowing abruptly to slender, prehensile tail; no caudal fin ..... Sea horse, p. 177
Head roughly cylindrical; body very slender with no distinction into trunk and tail portions; caudal fin present 2
2. Snout no longer than dorsal fin; no ventral fin; caudal fin rounded ..... Pipefish, p. 175
Snout more than six times as long as dorsal fin; ventral fins present; caudal fin forked ..... Trumpetfish, p. 173

Key C

Fishes with bills or swords (from No. 4, p. 11).

1. Both jaws elongated 4
Only one jaw elongated 2
2. Upper jaw elongated as a sword 3
Lower jaw elongated ..... Halfbeak, p. 163
3. Sword sharp-edged; first dorsal fin shorter than the sword forward of eye; no ventral fins ..... Swordfish, p. 221
Sword round-edged; dorsal fin nearly twice as long as sword ..... Spearfish,[6] p. 227
4. Caudal fin well developed 5
No caudal fin; tip of tail is whiplike ..... Snipe eel, p. 88
5. Several finlets behind dorsal and anal fins ..... Needlefish, p. 164
No finlets behind dorsal and anal fins ..... Silver gar, p. 161

Key D

Fishes with well-developed fins, snouts of ordinary form, only one gill opening on each side, and the anal fin continuous with the caudal around the tip of the tail (from No. 13, p. 11.)

1. Only one dorsal fin 2
Two separate dorsal fins, the first much higher than the second but shorter 6
2. Body band-shaped, the tail tapering to a whiplike tip ..... Cutlasfish, p. 220
Body thick, eel-like; vertical fins continue around tip of tail in a broad band 3
3. Dorsal fin spiny from end to end 4
Dorsal fin soft rayed, at least for almost all its length 5

[6] The sailfish would also come under this heading should one ever be taken in the Gulf of Maine. The distinctions between it and the spearfish are given under the account of the latter on page 228.

Key D—Continued

4. Mouth large and strongly oblique; no ventral fins ..... Wrymouth, p. 368
   Mouth small and horizontal; small ventral fins ..... Rock eel, p. 359
5. Without ventral fins ..... Eel family key, p. 78
   Small but distinct ventral fins, situated forward of the pectorals 6
6. Ventrals are situated behind the gill opening ..... Eelpout family key, p. 376
   Ventrals situated on the chin, well in front of the gill openings, and reduced to forked, barbel-like structures ..... Cusk eel, p. 384
7. Ventral fins situated below point of origin of pectorals; eye very large ..... Grenadier family key, p. 467
   Ventral fins situated behind tip of pectorals; eyes very small ..... Chimæra, p. 73

Key E

Bony fishes with two kinds of dorsal fins, i. e., one in front supported by rays, with a fleshy (adipose) fin behind it.[7] (From No. 14, p. 11.)

1. Rayed dorsal fin much longer than head, and spiny ..... Lancetfish, p. 155
   Rayed dorsal fin shorter than head, and soft-rayed 2
2. Jaws armed with long projecting saber-like fangs ..... Viperfish, p. 153
   Teeth small 3
3. Noticeable series of phosphorescent organs along each side 4
   No phosphorescent organs 6
4. Mouth gapes back beyond eye ..... Lanternfish family, p. 149
   Mouth does not gape back as far as eye ..... Pearlsides, p. 151
6. Tail deeply forked; nose pointed ..... Smelt family key, p. 140
   Tail nearly square or only slightly forked; nose rounded ..... Salmon family key, p. 126

Key F

Bony fishes with snouts of ordinary form, symmetrical tails, bodies not entirely encased in bony plate, caudal fins distinct from anal, and two or more well-developed dorsal fins, all of them supported by rays or spines (from No. 19, p. 12).

1. All fins soft rayed; no spines ..... Cod and silver hake families key, p. 385
   First dorsal fin spiny; second soft-rayed 2
2. One or more small finlets between second dorsal and anal fins and the caudal 3
   No such finlets 4
3. More than 3 each dorsal and anal finlets ..... Mackerel family, p. 188
   Two dorsal and two anal finlets ..... Escolar, p. 220
   Only one dorsal and one anal finlet ..... Mackerel scad (pompano family in part), p. 232
4. Sides of head bony, with sharp spines or horns; head very broad 5
   Sides of head have no spines or horns; head not noticeably broad 6
5. Three lower rays of each pectoral fin separate from others, in the form of fleshy feelers; outline of tip of snout, as seen from above, concave; mouth small ..... Sea robin family key, p. 345
   Lower rays of pectorals not separate from others; outline of tip of snout convex, not concave; mouth very large ..... Sculpin family key, p. 314
6. First spine of first dorsal fin very much stouter than others and can be locked erect by the second; no ventrals; skin very hard ..... Triggerfish, p. 293
   First dorsal spine not stouter than others; ventral fins well developed; skin soft 7
7. Ventrals more than twice as long as pectorals; caudal very small ..... John Dory, p. 291
   Ventrals no longer than pectorals; caudal fin large 8
8. Space between two dorsal fins is as long as the first dorsal; ventrals are situated behind the middle of the pectorals 9
   Little or no free space between the two dorsal fins; ventrals in front of middle of pectorals 10

[7] The tilefish (pp. 11 and 352) has a fleshy flap, simulating an adipose fin, on the back in front of the rayed dorsal fin.

Key F—Continued

9. Eyes large; mouth large and very oblique ..... Silverside family key, p. 178
   Eyes small; mouth very small and longitudinal ..... Mullet, p. 182
10. Caudal peduncle extremely slender; caudal fin deeply forked ..... Pompano family (in part) key, p. 229
   Caudal peduncle moderately deep; caudal fin at most moderately forked 11
11. First (spiny) dorsal fin much lower than second (soft rayed) dorsal ..... Bluefish, p. 237
   First dorsal as high as second, or higher 12
12. Second dorsal fin not much longer than anal ..... Sea-bass family (in part) key, p. 251
   Second (soft rayed) dorsal about twice as long as anal fin ..... Weakfish family key, p. 269

Key G

Bony fishes with snouts of ordinary form, symmetrical tails, bodies not clad in bony plates, caudal fin distinct from the anal, neither canine tusks nor barbels on the top of the snout, and only one dorsal fin which is soft-rayed except that it may commence with one short spine (from No. 22, p. 12). There is no adipose fin or flap either in front of the dorsal fin or behind it.

1. Tail deeply forked 2
   Tail square or rounded 12
2. The whole of anal fin is behind the dorsal ..... Herring tribe key, p. 90
   Part or all of anal fin in front of rear margin of dorsal 3
3. Mouth gapes back beyond eye 4
   Mouth does not gape beyond eye 6
4. Series of phosphorescent spots on each side 5
   No phosphorescent spots or organs ..... Anchovy, p. 124
5. Eye very large ..... Lanternfish family, p. 149
   Eye very small ..... Cyclothone, p. 153
6. Eel-like in form ..... Launce, p. 183
   Not eel-like in form 7
7. Large ventral fins 8
   Ventral fins wanting or very minute 10
8. Front portion of dorsal fin very high; body very deep ..... Opah, p. 242
   Dorsal fin not very high, tapers slightly from front to rear; general form slender, only about one-fifth as deep as long ..... Pilotfish, p. 229
10. First dorsal rays very elongate with tiny ventral fins; deep and compressed in form ..... Lookdown (adult), p. 236
   First dorsal ray not elongate 11
11. Dorsal profile of head convex; forward portion of dorsal fin at least three times as high as rear part, narrowing abruptly; no ventral fins ..... Butterfish family key, p. 245
   Dorsal profile of head concave; dorsal fin tapers only slightly from front to rear; minute ventral fins ..... Moonfish, p. 235
12. Dorsal fin preceded by one or more stout, isolated spines, with or without triangular fin membranes 13
   No isolated spines in front of dorsal fin 15
13. Only one stout dorsal spine, situated over the eye; body very deep ..... Filefish family key, p. 294
   Several dorsal spines, all far behind the eye 14
14. Ventrals large, of ordinary form; caudal peduncle stout ..... Barrelfish, p. 243
   Each ventral consists of one very large stout spine, with or without a small fin membrane and one or two short weak rays; caudal peduncle very slender ..... Stickleback family key, p. 166

Key G—Continued

15. No ventral fins, fishes capable of inflating themselves with air---------- Puffer and porcupine-fish families key, p. 297
Ventral fins present; can not inflate themselves with air---------- 16
16. Dorsal fin runs whole length of back, from nape to base of caudal, which it joins; barbel on chin; form eel-like---------- Cusk (cod family in part), p. 462
Dorsal fin occupies only one-third or less of back behind nape, leaving open space as long as fin between it and base of caudal; no barbel on chin; form not eel-like---------- Mummichog family key, p. 155

Key H

Fishes as in Key G, except that at least the forward one-third of the dorsal fin is spiny (from No. 22, p. 12). There is no adipose fin behind the rayed dorsal, nor fleshy flap in front of it.

1. Rear part of dorsal fin soft rayed---------- 2
Whole length of dorsal fin spiny---------- 7
2. Sides of head bony, with knobs or spines---------- 3
No knobs or spines on sides of head---------- 4
3. Sides of head with conical spines; spiny portion of dorsal fin at least as long as soft part; body laterally compressed---------- Rockfish family, p. 304
Sides of head with low rounded knobs; spiny portion of dorsal fin considerably shorter than soft part; body tadpole-shaped-- Deep-sea sculpin (sculpin family in part), p. 329
4. Ventral fins much longer than pectorals; eye very large---------- Big-eye, p. 261
Ventral fins no larger than pectorals; eye not very large---------- 5
5. Pectorals pointed; body much compressed---------- Sea bream family key, p. 263
Pectorals rounded; body not much compressed---------- 6
6. Rear (soft) portion of dorsal fin nearly as long as anterior (spiny) part; anal much higher than long---------- Sea bass (sea bass family in part), p. 251
Rear (soft) portion of dorsal fin less than half as long as spiny part; anal much longer than high---------- Cunner family key, p. 280
7. Mouth strongly oblique; no ventral fins---------- Wrymouth, p. 368
Mouth not strongly oblique; ventral fins present (very small in one species)---------- Blenny family key, p. 359

THE LAMPREYS. CLASS MARSIPOBRANCHII

Except for Amphioxus and its allies, the lampreys are the most primitive of vertebrates, their skeletons being cartilaginous and their skulls hardly differentiated from the vertebral column. They have no true jaws, no ribs, no shoulder or pelvic girdles, and no paired fins. They are eel-like in appearance, but are easily distinguishable from the true eels and, indeed, from most of the true fishes by the peculiar jawless sucking mouth situated at the tip of the snout, and from all Gulf of Maine eels by the absence of pectoral fins.

THE HAGFISHES AND LAMPREYS. FAMILIES MYXINIDÆ AND PETROMYZONIDÆ

These two groups are easily distinguished by the fact that the hags have but one gill opening on each side, one continuous fin on the back, and several barbels on the snout, whereas in the true lampreys there are seven gill openings on each side, the fin on the back is separated into dorsal and caudal portions, and there are no barbels on the snout.

1. **Hagfish** (*Myxine glutinosa* Linnæus)

Jordan and Evermann, 1896–1900, p. 7.

Description.—The hag, like the lamprey, lacks paired fins and fin rays. Its skeleton is wholly cartilaginous, without bones, its mouth is similarly jawless, and its skin is scaleless. It is easily recognized by its eel-like form; by its single finfold (a fold of skin, not a true fin) running right around the tail and forward on the lower surface of the body with no division into dorsal, caudal, and anal fins; by the single gill pore on each side, just forward of the origin of the ventral finfold; by its lipless mouth, stellate in outline when closed; by the single nasal aperture at the tip of the snout; by its peculiar barbels or "tentacles," two flanking the mouth on either side and four surrounding the nostril; and by the evertible tongue studded with rows of horny rasplike "teeth." We might also mention the series of mucus sacs on either side of the abdomen, and point out that the dorsal finfold originates two-thirds and

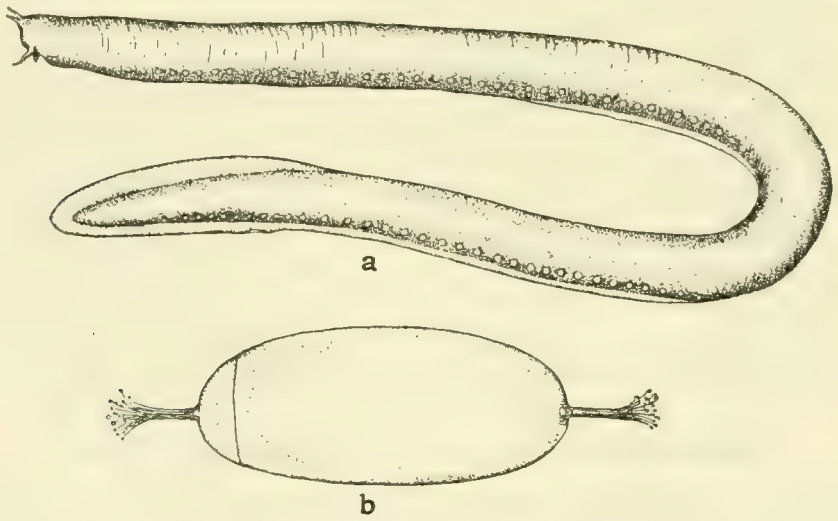

FIG. 2.—Hagfish (*Myxine glutinosa*). *a*, Adult. *b*, Egg. After Dean

the ventral one-third the distance back from snout to tip of tail, with the vent piercing it.

Hags vary in color, perhaps to correspond with the color of the bottom. They are grayish brown or reddish gray above, variously suffused, mottled, or piebald with darker or paler gray, brown, or bluish; below they are whitish or pale gray. They grow to a length of about 1 foot to a foot and a half.

General range.—Arctic seas and both coasts of the north Atlantic; south in deep waters to the latitude of Cape Fear, N. C. (33° 50′ N.).

Occurrence in the Gulf of Maine.—The hag is only too common in the Gulf of Maine; perhaps it is not absent from any considerable area of smooth bottom. Thus it is abundant generally off the north end of Grand Manan, is reported from Passamaquoddy Bay and from various localities near Eastport, is to be found offshore on muddy bottom all along the Maine coast, is caught at times in considerable numbers

on the Boon Island—Isles of Shoals fishing ground and about Jeffreys Ledge, where we found it plentiful enough in the spring of 1913 to have gutted 3 to 5 per cent of all the haddock in the gill nets. Fishermen report it as equally numerous in the deeper parts of Massachusetts Bay. On the offshore banks the hag is well known, and it has been trawled at various localities along the outer edge of the continental shelf off New England at depths of from 100 to 200 fathoms, and deeper. We ourselves took 11 large ones in one set of the Monaco deep-sea trap in 260 fathoms off Nantucket on July 9, 1908, and it has been taken in from 300 to 500 fathoms off Marthas Vineyard.

Habits.—The hag is not a true parasite, as has sometimes been suggested, there being no reason to believe it ever attacks living, uninjured fish, but it is a scavenger. Judging from its habits during the brief time it survives in aquaria, it spends its time lying embedded in the clay or mud with the tip of the snout projecting, but it is an active swimmer. Probably it finds its food by its greatly specialized olfactory apparatus. So far as is known it feeds chiefly on fish, dead or disabled, though no doubt any other carrion would serve it equally well, were such available. It is best known for its troublesome habit of boring into the body cavities of hooked or gilled fishes, eating out first intestines and then the meat, finally to leave nothing but a bag of skin and bones, inside of which, or clinging to the sides of a fish it has just attacked, the hag itself is often hauled aboard. In fact, it is only in this way, or entangled on lines, that hags ordinarily are taken or seen. Being worthless itself, it is an unmitigated nuisance and a particularly loathsome one, owing to its habit of pouring out slime from its mucus sacs in quantity out of all proportion to its small size. One hag, it is said, can easily fill a 2-gallon bucket, nor do we think this is any exaggeration.

The hag is at home only in comparatively low temperatures—cooler, probably, than 50°—and this confines it to depths of 15 to 20 fathoms or more in the Gulf of Maine in summer.

Breeding habits.—The hag and its immediate relatives are hermaphrodites—the only regularly effective ones in the whole vertebrate series, except for a very few species of bony fishes. Its single unpaired sex organ first develops sperm in the rear, then eggs in the forward portion.[8]

Further than this our knowledge of its breeding habits is still of the scantiest. Probably there is no definite spawning season, but eggs may be laid at any time of the year, for females near ripeness and others nearly spent have been recorded for various months, winter and spring as well as summer and autumn, and eggs have been taken in Norwegian waters from November to May. It has long been known that the eggs are large (up to 20 mm. in length), tough-shelled, and comparatively few (only 19 to 25 nearly ripe eggs having been counted in any one fish), and that they are very characteristic in appearance, for at each end they bear a cluster of barb or anchor tipped filaments (fig. 2b). Up until 1900 none had been found about which it could be asserted without hesitation that they had been laid naturally. In that year, however, Dean (1900) described hag eggs from the northwest part of Georges

[8] For an account of the sex organ of the hag see Schreiner (Biologisches Centralblatt, XXIV Band, Nr. 3, February, 1904, pp. 91–104). For a summary of earlier studies see Smitt (Scandinavian Fishes, 1892, p. 1205).

Bank and from the south coast of Newfoundland. Jensen [9] described others from the neighborhood of the Faroe Islands, and since then Huntsman has recorded them from the mouth of the Bay of Fundy and Hjort [10] from Norway. The eggs are demersal and stick fast in clusters to some fixed object—in Jensen's case to a Bryozoan—both by their filaments and by slime threads. Newly hatched hags have never been seen, but inasmuch as the smallest yet described (about 2½ inches long), probably not long out of the egg, already resembled the adult in external appearance there is no reason to suppose that the hag passes through a larval stage greatly different from the adult. The few egg finds thus far reported, being from 50 to 150 fathoms, point to rather deep water for the spawning of the hag. The Norwegian eggs mentioned by Hjort (taken in shrimp trawls) were on ooze bottom, but whether the hag invariably seeks this type of ground for breeding remains to be learned. I need only add that, to judge from Cunningham's experience with hags in aquaria, the females cease to feed with the approach of sexual maturity, as do so many other fishes.

2. Sea lamprey (*Petromyzon marinus* Linnæus)

LAMPREY; SPOTTED LAMPREY; LAMPER; EEL-SUCKER; GREAT SEA LAMPREY

FIG. 3.—Sea lamprey (*Petromyzon marinus*)

Jordan and Evermann, 1896–1900, p. 10.

Description.—Lampreys are very primitive vertebrates, eel-like in appearance, with soft, cartilaginous skeleton. They lack paired fins but have well developed dorsal and ventral finfolds. In the adult the jaws are so rudimentary that apparently they are wanting; the mouth is a longitudinal slit when closed, but when open forms an elliptical disk at the tip of the snout and is armed with many horny, hooked teeth arranged in numerous (11 to 12) rows, the innermost the largest. There are seven pairs of open gill slits and two dorsal fin folds, whereas the hag has but one pore on each side and only one fin. The sea lamprey (the only member of its group known from our salt waters) can hardly be mistaken for any other fish, its eel-like appearance coupled with the jawless mouth sufficing to place it at a glance.

Color.—In color the sea lamprey varies with locality, and perhaps with age and season also. It is usually described as mottled above—hence the vernacular name "spotted lamprey"—and plain tinted below. While the ground color of the upper

[9] Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i Kjøbenhaven, 1900, p. 1.

[10] Fishing experiments in Norwegian Fjords, by Johan Hjort and Knut Dahl. Report on Norwegian Fishery and Marine Investigations, Vol. I, 1900, No. 1, Chap. IV, p. 75. Kristiania.

surface of the body of lampreys from Massachusetts Bay is perhaps most often olive brown mottled with darker brown or black (the dark patches almost confluent), a plain bluish variety has been described, as have lampreys with the ground color yellowish brown, greenish, reddish, and bluish. Occasionally they are plain colored, but usually variously mottled. Perhaps the color of the bottom on which they live determines the color of lampreys as it does of so many other fishes. The lower surface is whitish, gray, or a pale shade of the same hue as the ground color of the back. During the breeding season lampreys (at least the landlocked form) are described as taking on more brilliant hues, the ground color between the dark spots turning bright yellow.

Size.—The lamprey rarely grows to a length of 3 feet and a weight of 5 pounds or more. Usually, however, adults, as they run up our rivers, are 2 to 2½ feet long.

General range.—Atlantic coasts of Europe and North America, from Labrador south to Florida in the western Atlantic. The lamprey spends most of its life in salt or brackish water, but ascends fresh-water rivers to spawn.

Occurrence in the Gulf of Maine.—No doubt the sea lamprey occurs along the whole coast line of the Gulf of Maine, for it is recorded in or at the mouths of numerous rivers and streams in Nova Scotia, New Brunswick, Maine, and Massachusetts, specifically in the St. John and Shubenacadie Rivers and from the St. Andrews region in salt water in the Bay of Fundy; from Eastport, Bucksport, Casco Bay, and the Presumpscott and Penobscot Rivers in Maine; from the Merrimac River; and from various stations in Massachusetts Bay, where it has been taken from time to time attached to driftwood and to the bottoms of boats as well as fastened to fishes. In olden times lampreys entered the Merrimac River in extraordinary numbers, but hard fishing has depleted their ranks sadly. Like other anadromous fishes, though they may seem plentiful enough when condensed in the narrow bounds of river banks, the stock probably is in no wise comparable with that of the commoner schooling fishes. Certainly they are not seen very often in the open sea. Probably at one time there was a run of lampreys in all the larger streams emptying into the Gulf of Maine, and they are still to be caught in the Merrimac, Kennebec, Penobscot, St. John, and Shubenacadie, and no doubt in sundry other rivers where we, personally, have no direct knowledge of them.

Habits.—Large lampreys have long been known to run up New England rivers a little earlier in spring than do shad, possibly commencing to work upstream as early as the end of April. They appear regularly in the Merrimac in May, and are most abundant there in June, after which few if any enter. They go far upstream, even to the headwaters, where they spawn in June and July. A sea lamprey has been found to contain 236,000 ova.

For the most complete survey of the life history of the lamprey we must turn to a landlocked race inhabiting certain lakes in the interior of New York and in Ontario. Briefly, it is as follows: [11] Such of the lampreys as approach

[11] For an account of nest building and spawning, which are hardly germane to the present study since they do not take place in salt water, the reader is referred to Gage (The lake and brook lampreys of New York, especially those of Cayuga and Seneca Lakes. The Wilder Quarter-Century Book, 1893, pp. 421–493, Pls. I–VII. Ithaca), Hussakoff (Sea lampreys and their nests. American Museum Journal, 1913, Vol. 13, p. 323), and to Coventry (Breeding habits of the landlocked sea lamprey, *Petromyzon marinus* var. *dorsatus* Wilder. University of Toronto Studies, Biological Series, No. 20: Publications of the Ontario Fisheries Research Laboratory, 1922, No. 9, p. 133. Toronto).

sexual maturity run up from the lakes into small clear brooks to spawn in June. As they ripen, the two sexes become dissimilar in appearance, the males (and this is equally true of sea-run fish both in American and European rivers) developing a ridge along the back, the females a finlike crest between the vent and the caudal fin. They build nests of round stones, which they drag together with their suckerlike mouths, as has often been described and pictured in natural histories, and after spawning apparently most, if not all, die, for not only have they often been found dead but their intestines atrophy, they are attacked by fungus, and they become so debilitated that recovery seems out of the question. In short, the old tradition that no lampreys return to the sea from the rivers they ascend seems well founded.

The larvæ are very different in appearance from the adults. They are blind and toothless, with mouths and fins of different shape. They continue in this state for a period estimated at 3 to 4 years, during most of which time they live in holes or burrow in the mud or sand, hiding under stones. Doctor Huntsman informs us, however, that they have been taken in tow nets in the Shubenacadie River in Nova Scotia. They subsist on minute organisms. At the end of this larval period, when they have grown to a length of 4 to 6 inches, they undergo transformation to the adult form and structure, an event occupying about two months—August to October—and descend the streams of their nativity to the sea just before the water freezes in November or December, to live and grow there for one or two years or until they reach full size and sexual maturity. The larvæ of the sea lamprey are very abundant in the mud of flats near the mouths of small tributary streams of such river systems as the Delaware and Susquehanna, where lampreys breed abundantly, and they have been reported in the Shubenacadie (a stream emptying into the Bay of Fundy) and no doubt occur in the Merrimac and other Gulf of Maine streams.

Although lampreys spawn but once and then perish, their period of growth is so long that large ones, not yet mature, are to be found in salt water all the year round.

Little is known of the habits of the lampreys while they live in the sea further than that the mode of life centers around a carnivorous nature. Judging from their landlocked relatives and from the occasions on which they have been found fastened to sea fish, they must be extremely destructive to the latter, which they attack by "sucking on" with their wonderfully effective mouths. Usually the lamprey fastens to the side of its victim, where it rasps away until it tears through the skin or scales and is able to suck the blood. Its prey sucked dry, it abandons it for another. Probably lampreys are parasites and bloodsuckers, pure and simple, for we can not learn that anything but blood has been found in their stomachs, except fish eggs, of which lampreys are occasionally full.[12] Lampreys have been found preying upon cod, haddock, and mackerel in Massachusetts Bay, even on basking sharks, and salmon, too, are said to be much annoyed by them. When not clinging to anything they are strong, vigorous swimmers, progressing by an undulating motion in the horizontal plane, and they are said to be exceedingly aggressive in their attacks on other fishes. Occasionally they are found fast to driftwood, even to boats.

[12] "The Fisheries and Fishery Industries of the United States," by George Brown Goode. Section I, 1884, p. 677. Washington.

How far offshore lampreys wander is not known. Probably, however, most of them remain in the coastal zone, if not in estuaries, and there is no evidence that they ever descend to any considerable depth. A few were brought in from Georges and Browns Banks, however, during the early years of the Bureau of Fisheries.[13]

Since lampreys never take the hook or are captured in nets except on rare occasions they are seldom seen in salt water; only when running up our rivers are they familiar objects.

In Europe, during the middle ages, lampreys were esteemed a great delicacy—historians tell us Henry I of England died of a surfeit of them—and formerly, when they were much more plentiful than nowadays, considerable numbers were captured in the rivers of New England, particularly in the Connecticut and Merrimac Rivers. They were, indeed, regularly sought in the former until well into the last half of the past century, but for 40 years now the lamprey fishery has been hardly more than a memory except locally and in a small way for home consumption. In the salt water of the Gulf of Maine the lamprey has never been of any commercial importance; the average fisherman might not see one in a lifetime, nor is there any sale for the few picked up by chance.

TRUE FISHES. CLASS PISCES

Sharks and rays. Subclass Elasmobranchii

The most obvious external character by which all sharks and rays are distinguishable from the bony fishes is that there are five or more pairs of gill openings on either side of the neck, instead of only one. In this they agree with the lampreys, but it is a commonplace that their jaws and teeth are extremely well developed. Their skins are tough and leathery and studded with denticles (placoid scales), which but remotely suggest ordinary scales and which are not homologous with the scales of bony fishes, for both dermis and epidermis take part in their formation, instead of the former alone. The teeth of the sharks and rays are essentially such placoid scales modified and simply embedded in the gums, not in the jaws. The fins are supported at their bases with segmented cartilaginous rods, and further out by numerous slender horny fibers, instead of by such rays or spines as are to be seen in the bony fishes. All the fins are covered with the same leathery skin that clothes the body. Among sharks the tail is uneven, with the vertebral column extending out into its upper lobe, but in most skates and rays it is whiplike, with no definite caudal fin. The torpedo (p. 68) is an exception to this rule.

The skeleton is for the most part cartilaginous, the skull far simpler than it is among the bony fishes, and the gills are attached throughout their lengths to the partitions between the gill openings instead of being free, while the rear portion of the digestive tract is modified into the so-called "spiral valve" by the development of a special fold from its lining layer. Sharks are usually looked upon as the most primitive of the true fishes.

[13] Report of the Commissioner of Fish and Fisheries for 1879 (1882), pp. 811, 812, and 814. Washington.

SHARKS

Sharks are always objects of interest, not only to fishermen and mariners but to seaside visitors generally, because of their evil appearance, their ferocity, the large size to which some of them grow, the destruction they wreak on fishermen's nets and lines as well as on the smaller fishes on which they prey, and the bad reputation certain kinds have earned, rightly or wrongly, as man-eaters.

The Gulf of Maine is not particularly rich in sharks (compared with our southern coasts, very poor indeed), for while the number of species actually recorded there is considerable (indeed any high-seas shark might straggle thither) the little spiny dogfish alone is numerous in the sense in which this term is applied to the various commercial fishes. Only one of the larger species, the mackerel shark (*Isurus punctatus*), visits us in numbers sufficient for one to be fairly sure to see it during a summer's boating off the coast north of Cape Cod. With the larger sharks generally so scarce (the mackerel shark is weak-toothed and perfectly harmless to anything larger than the fishes on which it feeds), the danger of attacks on bathers is negligible. Indeed, not a single well-authenticated instance of the sort is on record[14] for the past 80 years for the coast north of Cape Cod, though the beaches yearly are crowded with vacationists. As long as the white shark occasionally strays into the Gulf, however (p. 40), it is always remotely possible that some summer we may be horrified by the news of such a tragedy as occurred on the New Jersey coast in July, 1916, when several persons were killed or injured, presumably by a shark of this species that was captured nearby a few days later.[15]

Most Gulf of Maine sharks—certainly all the commoner ones—are viviparous, giving birth to young not only practically adult in structure but of relatively large size at birth.

As sharks are of little commercial value in the Gulf of Maine (attempts to introduce the dogfish as a food fish having failed so far) they are an unmitigated nuisance to the fishermen because of their damage to nets and other gear.

It is possible to identify all sharks so far known from the Gulf—and this includes all that are apt to occur there except as strays—by the size, structure, and relative locations of the fins, and by such tooth characters as may be seen at a glance at the open mouth or easily felt with the finger (after the shark is dead!).

In the following descriptions of the several species we have attempted to present only such features as will tell what shark is at hand; for more minute particulars we refer the reader to Garman's monograph (1913), which is not only the most authoritative work on this group of fishes, but in which almost all our species are beautifully pictured.

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[14] In 1830—an event often quoted—one Joseph Blaney, fishing from a small boat in Massachusetts Bay off Swampscott, Mass., was attacked by some fish that was seen to overset and sink his boat and presumably devoured him, for neighboring fishermen, who hastened to his rescue, found no trace of him. Whether his attacker was a large shark or, as we think more likely, a killer whale, is an open question.

[15] Murphy and Nichols (The shark situation in the waters about New York. The Brooklyn Museum Quarterly, Vol. III, October, 1916, No. 4, pp. 145–160. Brooklyn) give a detailed account of this occurrence.

KEY TO GULF OF MAINE SHARKS

1. Head hammer-shaped ..... Hammerhead, p. 31
   Head of ordinary shape; rounded or pointed nose 2
2. Only one dorsal fin; six gill slits on each side; body eel-shaped ..... Eel shark, p. 24
   Two dorsal fins (the second may be small but is always perfectly distinct); only 5 gill slits; body of ordinary shark form 3
3. Both dorsal fins have spines at their forward margins; no anal fin 4
   Dorsal fins lack spines 6
4. Rear margin of upper lobe of tail not notched; a very common species ..... Spiny dogfish, p. 44
   Rear margin of upper lobe of tail notched near the tip 5
5. Dorsal spines so small they are hardly visible, though easily felt ..... Portuguese shark (*Centroscymnus cælolepis*), p. 51
   Both dorsal spines large ..... Black dogfish, p. 53
6. There is no anal fin, the paired ventrals being the only fins on the ventral surface 7
   Anal fin present 8
7. First dorsal fin situated about midway between pectorals and ventrals ..... Greenland shark, p. 53
   First dorsal far back as ventrals ..... Bramble shark (*Echinorhinus brucus*), p. 55
8. No lateral keels on caudal peduncle (root of tail); upper lobe of caudal fin much longer than lower 9
   A longitudinal keel on either side of caudal peduncle; lower lobe of tail more nearly as large as upper, suggesting tail of a swordfish 14
9. Upper lobe of caudal fin nearly, if not quite, as long as head and body together ..... Thresher, p. 32
   Caudal fin less than half as long as head and body combined 10
10. Second dorsal at least half as high as first 11
    Second dorsal less than half as high as first 12
11. Second dorsal considerably smaller than first; teeth small, blunt, and arranged like a pavement ..... Smooth dogfish, p. 24
    Second dorsal about as large as first; teeth narrow and pointed ..... Sand shark, p. 34
12. Origin of first dorsal hardly behind pectorals; upper and lower teeth alike; skin spotted ..... Tiger shark, p. 27
    First dorsal originates well behind the pectorals; upper teeth broader than lower; skin not spotted 13
13. The first dorsal originates about over the inner corner of the pectorals when these are laid back; snout broadly rounded ..... Dusky shark,[16] p. 29
    First dorsal originates far behind inner corner of pectoral; snout long and pointed ..... Blue shark, p. 28
14. Gill slits very long; first pair nearly meeting on throat; gills with rakers; teeth tiny ..... Basking shark, p. 41
    Gill slits short, confined to sides of neck; no gill rakers; teeth large 15
15. Teeth broad, triangular, with serrate edges; second dorsal fin well forward of anal ..... White shark, p. 39
    Teeth slender, smooth-edged; second dorsal fin over or hardly in front of anal 16
16. First dorsal fin originates above axil (armpit) of pectoral ..... Mackerel shark (*Isurus punctatus*), p. 36
    First dorsal fin originates well behind the axil f pectoral ..... Sharp-nosed mackerel shark (*I. tigris*), p. 38

[16] The brown shark (*Carcharinus milberti*), very abundant west and south of Cape Cod but not yet known from the Gulf, is easily distinguished from its close relative, the dusky shark, by its very tall dorsal fin.

THE EEL SHARKS. FAMILY CHLAMYDOSELACHIDÆ

3. Eel shark (*Chlamydoselachus anguineus* Garman)

FRILLED SHARK; SNAKE SHARK; SEA SERPENT

Jordan and Evermann, 1896–1900, p. 16.
Garman, 1913, p. 14.

Description.—The readiest field marks for this curious shark are the eel-like form of its body and tail, the fish being about fifteen times as long as deep; the fact that there is only one dorsal fin, situated far back over the anal but smaller than the latter; that there are six gill openings on a side instead of five; and that the mouth is more nearly terminal than in most sharks, with the snout hardly projecting

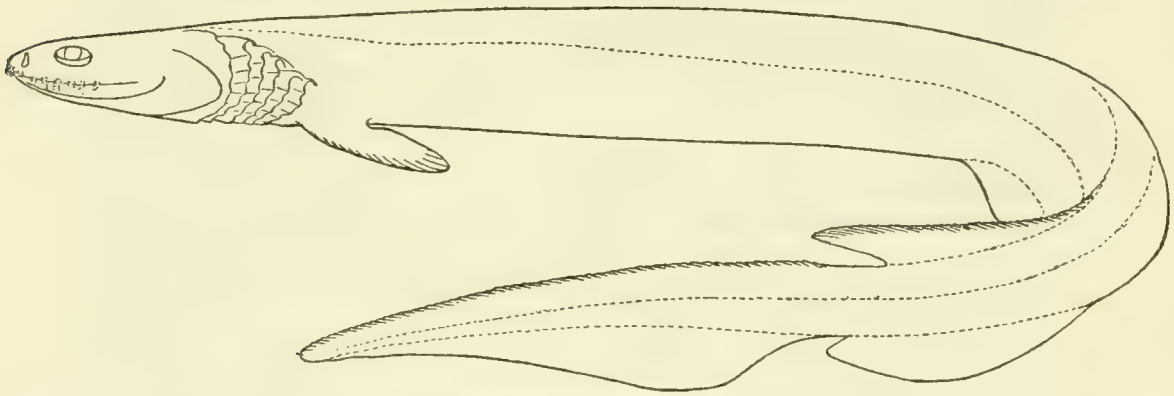

FIG. 4.—Eel shark (*Chlamydoselachus anguineus*). After Goode and Bean

beyond it. The pectorals, it may be added, are relatively small; the ventrals are larger and close in front of the anal.

Size.—The few eel sharks so far recorded have been from 2 to 5 feet long.

Color.—Uniform brown.

General range.—Probably cosmopolitan in the deep waters of temperate and tropical oceans. This shark has been taken, on several occasions, in Sagami Bay, Japan; also off New South Wales, Madeira, and Norway.

Occurrence in the Gulf of Maine.—A curious eel-like fish found dead in a net near Pemaquid Point, Me., in 1880 [17] may have been an eel shark, and this is its only claim to mention here. It would not be surprising should it stray into our Gulf along the trough of the basin from the open Atlantic, for it is as likely to live off our coast as off any other, so widely separated are the localities of capture, listed above.

[17] Described by Hanna (1883).

THE SMOOTH DOGFISHES. FAMILY GALEORHINIDÆ

These are rather small sharks (17 known species) with two dorsal fins, the first large and the second usually much smaller, without spines. The upper lobe of the tail is much longer than the lower, anal fins are present, and the teeth are flat and pavementlike. Except for the teeth they closely resemble the requiem sharks (family Carcharinidæ, p. 27).

4. Smooth dogfish (*Galeorhinus lævis* Valmont)

GRAYFISH; SMOOTH DOG; SMOOTH HOUND; SWITCH-TAIL; WHIPPER-TAIL

Jordan and Evermann (*Mustelus canis* Mitchill), 1896–1900, p. 29.
Garman, 1913, p. 176.

Description.—The smooth dog is easily identified by the presence of two large spineless dorsal fins, the first larger than the second, combined with an anal as well as the paired ventral fins on the lower surface; a tail of typical shark outline—that is, the upper lobe longer than the lower but not excessively elongated—and with flat granular teeth. So different, indeed, are the teeth from the cutting teeth

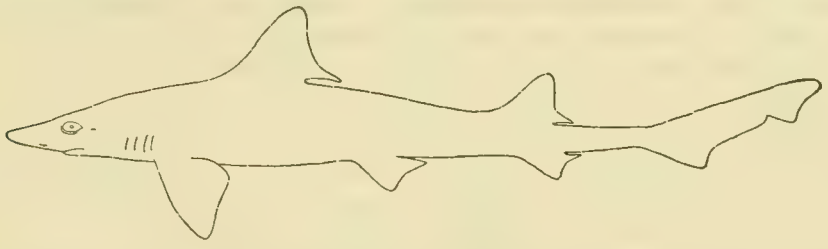

FIG. 5.—Smooth dogfish (*Galeorhinus lævis*)

of all our other sharks, that a glance at the mouth is enough to separate this species from the young of any larger Gulf of Maine shark. In form this little shark is slender, flattened below, with tapering but blunt snout. Its first dorsal originates nearly over the hind angle of the pectorals and is decidedly larger than the second. The latter, in turn, is about twice as large as the anal, over which it stands. The hind margin of the upper lobe of the caudal is deeply notched near the tip; the lower caudal lobe is very small.

Size.—Adult smooth dogs average about 2 to 3 feet in length, but they have been taken up to 5 feet in length.

Color.—Light gray above; paler gray below.

General range.—Cape Cod to Cuba in American waters; also off the coasts of southern Europe.

Occurrence in the Gulf of Maine.—The smooth dog is extremely abundant west and south of Cape Cod. In Long Island waters, for example, it is one of the commonest and most generally distributed of fishes from June until November, and it abounds equally throughout the summer and early autumn in the Woods Hole region on all kinds of bottom. This, however, is the most easterly outpost for its presence in any numbers, for though it has been reported from Provincetown,

from various localities within Massachusetts Bay, and even from as far north as St. Andrews in the Bay of Fundy, where one was caught in July, 1913, it occurs only as a southern straggler in the Gulf of Maine, and that so rarely that neither of the authors has ever seen it north of Cape Cod. So far as known its occasional incursions into the Gulf are sporadic—at least they have not been correlated with unusually warm summers or with the presence of other southern fishes.

On the outer part of the continental shelf Nantucket Shoals must be regarded as the easterly limit of its regular occurrence, for it is not recorded nor reported by fishermen from either Georges or Browns Banks, nor was it detected there by the representatives of the Bureau of Fisheries during the trawling investigations of the years 1912 and 1913 (p. 9).

The smooth dog is most familiar as a shore fish and a bottom swimmer, commonly entering shoal harbors and bays, nor is it known to descend to any considerable depth.

Food.—The food of the smooth dog consists chiefly of the larger Crustacea, and it is perhaps the most relentless enemy of the lobster, which had been eaten by no less than 16 per cent of the fish examined by Field (1907). Large crabs are likewise an important article in its diet, as are the smaller fishes. Field estimated that in Buzzards Bay 100,000 smooth dogfish would annually devour over 600,000 lobsters, 90,000 to 100,000 fish of one kind or another (menhaden and tautog are the species most often found in dogfish stomachs), and a couple of million crabs. While these figures are to be taken only as broadly suggestive, they are based on a sufficient number of observations of the stomach contents to serve as a general indication of the destructiveness of dogfish. They also feed on squid, especially in spring, and while they do not regularly take mollusks, razor clams have been found in the stomachs of several at Woods Hole. When kept in captivity they are constantly on the move, searching the bottom for food, which they find chiefly by the sense of smell though their sight is also keen.[18] Any crab that may be offered is soon found, seized, shaken to and fro, and eaten, and with packs of these sea hounds hunting over every square foot of our southern bays and sounds it is a wonder any of the larger Crustacea escape when dogfish are abundant. Field also made the interesting observation that the smooth dogs never molested healthy and active menhaden but soon devoured any sick or injured fish that might be in the same tank with them.

Breeding habits.—Not being a characteristic Gulf of Maine fish we need merely note of its breeding habits that it is viviparous,[19] giving birth to from 4 to 12 young at a litter, the pups being about a foot long and practically of adult form when born; and that in the Woods Hole region females containing eggs and embryos at various stages in development are to be found throughout the summer. How many litters of young are produced by any one female during a year is still to be learned.

[18] The senses of this shark have been studied by Parker (Bulletin, U. S. Bureau of Fisheries, Vol. XXIX, 1909 (1911), pp. 43–57) and by Sheldon (Journal of Comparative Neurology and Psychology, vol. 19, 1909, No. 3, p. 273).

[19] In the report of the Massachusetts Commissioners of Fish and Game for 1905 it is erroneously said to be oviparous, apparently being confused with the European dogfish, *Scyllium canicula*.

REQUIEM SHARKS. FAMILY CARCHARINIDÆ

This family, containing a large number of species in tropical and temperate seas, is characterized by a head of normal shape, tail with the upper lobe much larger than the lower but not greatly elongate, two spineless dorsal fins, the first usually much larger than the second and situated over the space between the pectorals and the ventrals, a caudal peduncle lacking lateral keels, and sharp teeth.

5. Tiger shark (*Galeocerdo arcticus* Faber)

Jordan and Evermann (*G. tigrinus* Müller and Henle), 1896–1900, p. 32.
Garman, 1913, p. 148.

Description.—The tiger shark is characterized among the "smooth" (spineless) sharks by the fact that it has an anal as well as ventral fins, that the upper lobe of the tail is much larger than the lower, that the second dorsal fin is very much smaller than the first, and that the latter originates little, if any, behind the "armpit" of the pectoral. The only Gulf of Maine shark with which it might be confused is the dusky shark (p. 29), but it is easily separable from the latter by the more forward position of the first dorsal fin and by the fact that it is spotted instead of plain colored. I may also note that its teeth are large and alike in both jaws.

The body is slender, rather heavy forward of the pectorals, and tapering toward the tail. The head is large, very short, and broad. The snout is rounded

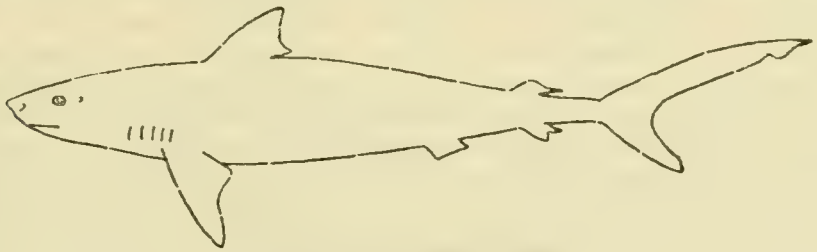

FIG. 6.—Tiger shark (*Galeocerdo arcticus*)

(not pointed) and the mouth is very broad, occupying nearly two-thirds of the width of the snout. The first dorsal is high, triangular, and nearly as large as the pectoral, while the second dorsal is hardly one-third to one-fourth as high as the first and stands over the anal, which is of about equal size. The lower tail lobe is almost half as long as the upper, the rear margin of which is notched near the tip.

Color.—Young tiger sharks are light brown, more or less spotted and barred with darker brown. These markings fade with advancing age until adults are nearly plain colored.

Size.—This is one of the largest sharks, frequently being 12 to 15 and occasionally as much as 30 feet in length, though such a size is altogether exceptional. Most specimens caught north of the Carolinas are small.

General range.—Cosmopolitan in the warmer waters of all oceans, whence it strays northward as far as Cape Cod on the American coast of the Atlantic.

Occurrence in the Gulf of Maine.—Every year a few young tiger sharks are taken in the fish traps in the Woods Hole region, where, according to the records of the Bureau of Fisheries, it is the latest shark to arrive, rarely being seen before August

or after October. The specimens captured there usually have been about 5 feet long, and very rarely does a full-grown tiger shark stray so far from its tropical home. But, curiously enough, one at least of the several specimens recorded from Provincetown, its furthest known outpost and the only locality where it has been captured in the Gulf of Maine, must have been of good size, for its stomach contained a whole full-grown swordfish.

Habits.—This slender, active, and voracious shark, with wide jaws and powerful teeth, is an inhabitant of the high seas, preying upon the large sea turtles, other sharks, fish, and occasionally on invertebrates such as horseshoe crabs, crabs, conchs, whelks, etc. Remnants of squeteague, mackerel, hake, scup, menhaden, goosefish, and dogfish all have been found in stomachs of tiger sharks taken at Woods Hole.[20] In the West Indies it is much dreaded, whether or not with good cause. So seldom does this species round Cape Cod (in fact none has been reported east or north of the cape for many years) that the chance of running across one in the Gulf of Maine is extremely remote. It has never been recorded from the offshore banks.

6. **Great blue shark** (*Galeus glaucus* Linnæus)

BLUE SHARK

Jordan and Evermann (*Prionace glauca* Linnæus), 1896–1900, p. 33.
Garman, 1913, p. 145.

Description.—The blue shark is slender bodied, thickest at about its mid-length, and tapering thence toward the head and tail (that is, the shape usually named "fusiform"), its long pointed snout separating it at a glance from the blunt-nosed tiger. The first dorsal is of moderate size, standing well behind the middle of the space between pectorals and ventrals. The pectorals are very long, their tips reaching as far back as the first dorsal, and their very narrow and pointed outlines, combined with the location of the first dorsal and the pointed snout, give it an aspect very different from that of the dusky shark, which resembles it in the relative sizes of the fins. The second dorsal is less than half as high as the first—about equal to the anal over which it stands. The lower lobe of the tail is only one-third as long as the upper. The latter is notched near the tip, and both tail lobes are sharp pointed.

The teeth of the blue shark are very characteristic, being large and serrate, each series forming a continuous cutting edge. Those of the upper jaw are broadly triangular with curved tips, while the lower teeth are narrower, pointed, and stand more erect.

Size.—The blue shark grows to a length of about 12 feet.

Color.—The color varies from grayish to light or bright steel blue, or even to bluish black above. Below it is dirty white.

General range.—Cosmopolitan in the warmer parts of all oceans. On the northeastern coast of North America it is taken from time to time at Woods Hole,

[20] Bell and Nichols (Copeia, No. 92, Mar. 15, 1921, pp. 17–20) list the stomach contents of a large number of tiger sharks caught off Morehead City, N. C.

where it is one of the rarer sharks, and at Nantucket. While only a stray in the Gulf of Maine, it must visit the outer coasts of Nova Scotia in some numbers every summer, for Harry Piers, of the Provincial Museum, Halifax, informs us that there are three specimens in the museum—one of them 10 feet 5 inches long—taken near Halifax. He also reports a fourth taken there in 1895, and writes that this shark was "plentiful at entrance to Halifax Harbor about 25 August, 1920; first seen about 15 August; last seen 23 September." Cornish [21] also saw two specimens at Canso, Nova Scotia, but whether the "blue dogs" described to him by local fishermen as common on the neighboring fishing banks actually are this shark seems doubtful. On the European side of the Atlantic the blue shark is not uncommon in summer around the south coasts of Great Britain, and has been taken casually as far north as southern Norway.

Occurrence in the Gulf of Maine.—The claim of this species to mention here rests on a single specimen from Massachusetts Bay recorded by Garman (1913), but being comparatively so common off Nova Scotia it is to be expected in the Gulf

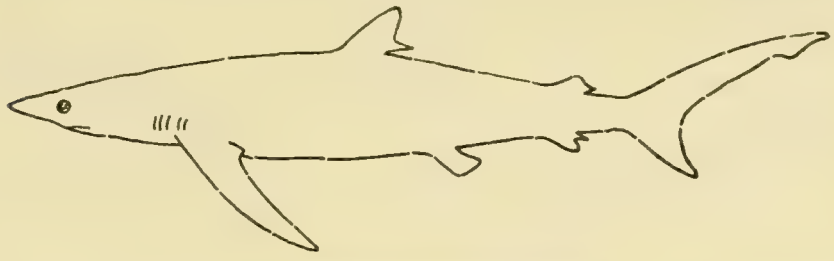

FIG. 7.—Great blue shark (*Galeus glaucus*)

any summer. It may be noted in passing that it is viviparous, and that Nichols and Murphy [22] have given a graphic account of it as it is met with by whalers on the high seas.

7. **Dusky shark** (*Carcharhinus obscurus* LeSueur)

SHOVELNOSE

Jordan and Evermann, 1896–1900, p. 35.
Garman, 1913, p. 130.

Description.—In the dusky shark (a moderately stout-bodied species) the second dorsal is not over one-half as high as the first. The latter stands well back of the pectorals, but, being nearer these than to the ventrals, is relatively further forward than in the blue shark and further back than in the tiger shark. The rear margin of the first dorsal is deeply concave; the pectorals are relatively long and narrow (twice as long as broad) and reach back as far as the rear edge of the first dorsal. The second dorsal is even smaller than the anal, over which it stands. The tail is long, occupying more than one-fourth of the total length of the shark,

[21] Further Contributions to Canadian Biology, 1902–1905 (1907), p. 81. *In* 39th Annual Report of the Department of Marine and Fisheries, 1906, Fisheries Branch. Ottawa.

[22] Brooklyn Museum Science Bulletin, vol. 3, No. 1, 1916, p. 9. Brooklyn.

but its lower lobe is relatively shorter than in either tiger or blue shark. The dusky shark is further distinguished from the latter by its blunt rounded nose and broad flat head. The upper teeth are broad, triangular, serrate, and with concave outer edges; the lower teeth are narrower, more pointed, with broad bases, and stand more erect.

Size.—This shark occasionally reaches a length of 14 feet, but the larger specimens caught in the traps are usually only 6 to 9 feet long. The relation of length to weight may be judged from the fact that one 11 feet 6 inches in length weighed 650 pounds.

Color.—Gray brown above; whitish below. It is said that this shark is sometimes blue above.

General range.—Middle Atlantic; from North Carolina to Portland, Me., on the coast of North America.

Occurrence in the Gulf of Maine.—Like several other sharks the shovelnose is sufficiently plentiful all along the shores of southern New England, as far east as

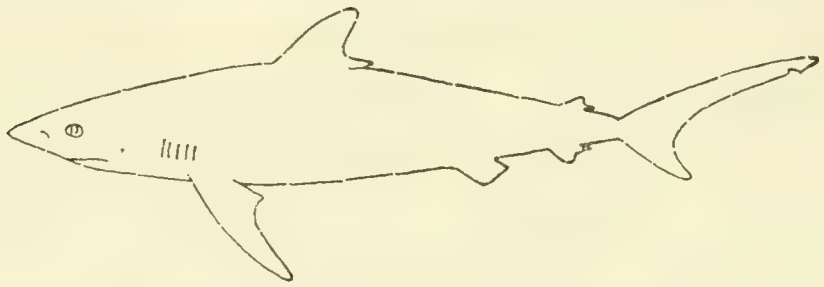

FIG. 8.—Dusky shark (*Carcharhinus obscurus*)

Cape Cod, throughout summer and early autumn, to be well known to the local fishermen. At Woods Hole, for example, it is very common, but it rarely strays into the colder waters beyond the cape. The localities within the Gulf of Maine where it has been definitely recorded are Crab Ledge off Chatham, Nahant, Massachusetts Bay, and Cod Ledge near Cape Elizabeth (the most northerly occurrence yet known), where one was caught in 1864 by Capt. B. J. Willard. So rare are these stragglers that neither of the writers has ever seen one in the Gulf. In short, it has no place in the fauna of the latter except as a stray. Neither recorded capture nor fishermen's report credits it to Georges or to Browns Bank.

Food.—The shovelnose is a bottom swimmer, feeding chiefly on fish and squid but also eating the larger Crustacea. Cunners, menhaden, scup, skates, and silver hake have been found in specimens caught at Woods Hole. It is harmless to human beings.

THE HAMMER-HEADED SHARKS. FAMILY CESTRACIONTIDÆ

The peculiar shape of the head, described below, sufficiently characterizes the only Gulf of Maine representative of this family, which otherwise resembles the requiem sharks (p. 27).

8. **Hammerhead shark** (*Cestracion zygæna* Linnæus)

Jordan and Evermann (*Sphyrna zygæna* Linnæus), 1896–1900, p. 45.
Garman, 1913, p. 157.

Description.—The bizarre outline of the head of the hammerhead, easier drawn than described, has been so widely heralded that probably everyone at all concerned with fishes is perfectly familiar with it. It can not possibly be confused with that of any other fish. The eyes stand at either edge of the "hammer"; the first dorsal fin originates slightly behind the "armpit" of the pectoral, is considerably larger than the latter, and is much higher than long; the very small second dorsal is hardly one-fifth as high as the first; the upper lobe of the tail is notably long (about one-third as long as the body of the fish) and deeply notched near the tip, the lower lobe hardly one-half as long as the upper.

Size.—The hammerhead is one of the larger sharks, growing to a length of 15 feet or more.

Color.—Gray to ashy brown above; paler brown to dirty white below.

General range.—A warm-water species, cosmopolitan in tropical seas northward to the Gulf of Maine in the western North Atlantic, and to British waters in the eastern North Atlantic.

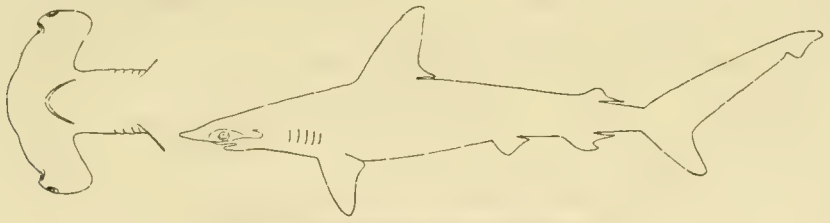

FIG. 9.—Hammerhead shark (*Cestracion zygæna*)

Occurrence in the Gulf of Maine.—The hammerhead, like most of its tropical relatives, finds Cape Cod and the cool water that it meets when it strays beyond that natural boundary the eastern and northern limit to its regular annual occurrence. In the Woods Hole region, only a few miles west of the cape, it is caught from time to time in the fish traps from July to October almost every year. So far, however, the only definite reports of it in the Gulf of Maine with which we are acquainted are from Chatham and Provincetown, the latter its most northerly record on the American coast; nor is it likely that the hammerhead is more common in the Gulf than these few records suggest, for so easily recognized is it among sharks that it is far more apt to be reported than are the various tropical species of more conventional appearance. It would not be surprising to see it on Georges or Browns Bank, though no rumor of its presence there has reached us.

With the hammerhead, as with many other tropical fishes, the examples that visit the shores of New England are usually small. At Woods Hole about 4 feet is the commonest length and 6 to 8 feet the maximum. In 1805, however, a specimen 11 feet long was netted at Riverhead, Long Island, N. Y., and the fact that

this specimen contained parts of a man in its stomach is chiefly responsible for the bad reputation of the hammerhead.

Habits.—The hammerhead is pelagic in habit, often swimming with dorsal and caudal fins above the surface. It feeds chiefly on fish and squids but is also known to eat crabs and even barnacles. It is viviparous. Thirty-seven embryos have been taken from the oviducts of a female 11 feet long, and probably such specimens as wander north of the Chesapeake Capes give birth to their young in summer, for specimens as small as 1½ feet long have been taken at Woods Hole in July and August.

THE THRESHER SHARKS. FAMILY VULPECULIDÆ

The only representative of this family (the well-known thresher) is peculiar among sharks for its enormously elongate tail. Its closest affinities otherwise are with the mackerel sharks (p. 35).

9. **Thresher** (*Vulpecula marina* Valmont)

THRASER; SWIVELTAIL; SWINGLETAIL; FOX SHARK

Jordan and Evermann (*Alopias vulpes* Gmelin), 1896–1900, p. 45.
Garman, 1913, p. 30.

FIG. 10.—Thresher shark (*Vulpecula marina*)

Description.—The thresher is as easily distinguished by its long tail as the hammerhead is by its head, the upper caudal lobe being about as long as the head and body of the fish together, curved much like the blade of an ordinary scythe, and notched near the tip, whereas the lower lobe is hardly longer than the anal fin. It need merely be pointed out in addition that the first dorsal (of moderate size and about as high as long) stands about midway between pectoral and ventral, that the second dorsal and the anal are very small, the pectoral is very long and sickle shaped, and that the thresher is a stout-bodied shark with short snout, blunt, rounded nose, and small triangular teeth.

Size.—The thresher grows to a length of about 20 feet or more, fish as large as 16 feet in length having several times been taken at Woods Hole. One of 13 feet has been found to weigh about 400 pounds.

Color.—Dark lead brown to nearly black above; white below, except that the lower sides of the pectorals are leaden in hue.

General range.—An inhabitant of all warm seas, especially numerous in the Mediterranean and temperate Atlantic.

Occurrence in the Gulf of Maine.—The most northerly locality on the east coast of the United States where the thresher can be called fairly abundant is off Block Island, where, say Nichols and Murphy,[23] it is the commonest large shark, appearing in May, most plentiful in June, and remaining until late in the fall. At Woods Hole, too, it has occasionally been taken in the fish traps from April until late in the autumn. Specimens as large as 20 feet in length have been caught there—three fish of 16 feet each in one trap in a single morning. Although only two specimens have been reported at Nantucket, the thresher evidently enters the Gulf of Maine more often than do most of its tropical relatives (e. g., the blue shark) for it has been recorded repeatedly on the coasts of Maine and Massachusetts—at Provincetown, Massachusetts Bay, Boston Harbor, Nahant, off Monhegan, east of Matinicus, off Penobscot Bay where a specimen estimated to weigh 500 pounds was caught in 1911, and off Eastport. It is said to have been taken—even to have been common—in the past in the Bay of Fundy, though there is no recent record of it there, and it has been reported entangled in nets off the Nova Scotian coast and even from the Gulf of St. Lawrence. To these records we can add that of several large threshers seen leaping near the *Grampus* as she sailed through Pollock Rip on August 4, 1913. In fact, next to the mackerel sharks (p. 35) the thresher is no doubt the commonest large pelagic shark in the Gulf. No doubt it also occurs in the mackerel season on Georges and Browns Banks, though we find no definite record of it there. The thresher is to be expected in our waters only in the spring, summer, and autumn; in the cold season it altogether deserts the northern coasts for warmer seas.

Food and habits.—The tale that the thresher leagues with the swordfish to attack whales is time honored, but it seems that it must be relegated to the category of myth, for few, if any, experienced whalemen can be found to credit it (except in yarns spun to entertain and awe landlubbers!), and so weak toothed is this shark that the second part of the story—that it makes a meal on its huge victim—is an impossibility. In actual fact the thresher feeds chiefly, if not exclusively, on such schooling fishes as mackerel, menhaden, herring (of which it destroys great numbers), and, in European waters, pilchard. A pair of threshers often work in concert "herding" a school of fish, and it is to frighten its prey together that its enormously long, flail-like tail is employed. Allen [24] gives an interesting eyewitness account of a thresher pursuing and striking a single small fish with its tail. It is, we may add, perfectly harmless to human beings.

Commercial importance.—In the Gulf of Maine the thresher is not common enough to be of any importance to fishermen one way or another, or to play a practical rôle of any moment among the smaller fish. Further south, however, and wherever it is numerous in the Atlantic, it makes itself a great pest, tangling and tearing mackerel nets as well as destroying and chasing away the more valuable fishes on which it feeds.

[23] Brooklyn Museum Science Bulletin, vol. 3, No. 1, 1916, pp. 1–34, pls. 1–3. Brooklyn.
[24] Science, New Series, Vol. LVIII, No. 1489, July, 1923, pp. 31–32.

THE SAND SHARKS. FAMILY CARCHARIIDÆ

In the sand sharks the two dorsal fins are spineless and nearly equal in size, the upper lobe of the tail is much larger than the lower, there are no keels on the caudal peduncle, and the teeth are very slender and pointed.

10. Sand shark (*Carcharias taurus* Rafinesque)

SHOVELNOSE; DOGFISH SHARK; BLUE DOG; LITTLE MACKEREL SHARK; GROUND SHARK

Jordan and Evermann (*Carcharias littoralis* Mitchill), 1896–1900, p. 46.
Garman, 1913, p. 25.

Description.—The large size of the second dorsal and anal fins (which are about equal to the first dorsal instead of much smaller) is of itself enough to distinguish this species from all other Gulf of Maine sharks. The first dorsal fin being located but little in front of the ventrals, the trunk seems crowded with fins of equal size—a useful field mark for this species. We may also point out that the pectoral fins are not much larger than the other fins —triangular rather than sickle shaped; that the upper lobe of the tail is nearly one-third as long as head and body together and notched near the tip, with the lower lobe about one-fifth as long as the upper; and

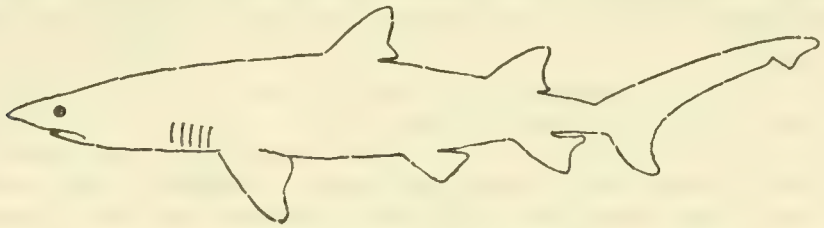

FIG. 11.—Sand shark (*Carcharias taurus*)

that the head is flat, the nose short and blunt at the tip. The teeth of the sand shark (they are alike in both jaws) are likewise diagnostic, being long, narrow, and pointed, with a spur at either side near the base, and smooth-edged.

Size.—Adult sand sharks are usually about 4 to 5 feet long, often a foot or more longer, and rarely taken up to 8 or 9 feet.[25] They have been reported up to 12 feet long, but this is so much longer than the general run as to raise the question whether these monsters were actually sand sharks and not some other species.

Color.—The ground color is gray, darker above, lighter below, indistinctly spotted with darker brown, and the edges of the fins are sometimes edged with black.

General range.—Coastal waters of the United States from Maine to North Carolina.

Occurrence in the Gulf of Maine.—The sand shark is the commonest of all its tribe (except the smooth and spiny dogfishes) at the westerly entrance to the Gulf of Maine. It is very plentiful at Woods Hole from June to November and is to be found everywhere in that region in shoal waters, even coming up to the wharves. At Nantucket, too, it is so abundant that shark fishing, with the sand shark as the chief objective, is a popular sport, and although we find it far less abundant once we

[25] Sherwood (Copeia, Nov. 15, 1921, No. 100, p. 77) records one of 8 feet 10 inches, caught at Clinton, Conn.

pass the southern elbow of Cape Cod, it is more often seen and taken in the Gulf of Maine than is any other large shark except the mackerel shark (p. 36) or perhaps the thresher. There is well-established record of its presence at Monomoy, North Truro, Provincetown (where it has been caught often enough to have received the local name of dogfish shark, appropriate because of its small size), Cohasset in Massachusetts Bay (where the senior author caught one about 4 feet long years ago), in Boston Bay, at Lynn, at the mouth of Casco Bay, and even near St. Andrews in the Bay of Fundy—its most northerly outpost—where a stray specimen was taken in a weir in 1913. Probably, were all the sand sharks that entangle themselves in nets reported, we would find that it ranges northward as far as Casco Bay every summer and in much greater numbers than the actual published record would suggest. Any "shovelnose" reported from northern New England would probably belong to this species; and no doubt it is represented among the "ground sharks" taken by fishermen on Georges Bank, though definite information is lacking on this point.

Habits and food.—This shark, in the warm months at least, swims chiefly near the bottom in shoal water, often coming right up on the beaches almost to tide mark and even entering the mouths of rivers. Over certain bars, however, it often comes to the surface, where it may be seen moving slowly to and fro with its dorsal and tail fins projecting above the surface. It captures great numbers of small fish, which are its chief diet, particularly menhaden, cunners, mackerel, skates, silver hake, flounders, alewives, butterfish, and—south of Cape Cod—scup, weakfish, and bonito. It also eats lobsters, crabs, and squid. Although comparatively sluggish in habit, as sharks go, sand sharks have been seen surrounding and devouring schools of bluefish, and have even been known to attack nets full of bluefish, which gives a measure of their voracity. There is no record or even well-grounded rumor that this shark ever attacks human beings. Indeed, it is looked upon merely as a harmless nuisance wherever it is common enough to be familiar. So far as the Gulf of Maine and, indeed, the southern coast of New England as a whole are concerned, the sand shark occurs only as a summer visitor, moving away either southward or into deep waters during the cold season.

Breeding habits.—Nothing is definitely known of its breeding habits. Females with unripe eggs have been taken at Woods Hole in July.

Commercial value.—This shark has no commercial value except the negative one of damaging nets, but so readily does it bite a hook that it is of some importance as an object of sport, though hardly so in the Gulf of Maine, where it is never plentiful enough to be worth fishing for.

THE MACKEREL SHARKS. FAMILY ISURIDÆ

This group of sharks is easily recognizable by the fact that the tail is very firm and lunate in outline with the lower lobe but little smaller than the upper, suggesting a swordfish's tail, and that there is a prominent keel on either side of the caudal peduncle. The dorsal fins are spineless.

11. **Mackerel shark** (*Isurus punctatus* Storer)

Blue shark; Porbeagle

Jordan and Evermann (*Lamna cornubica* Gmelin), 1896–1900, p. 49.
Garman, 1913, p. 36.

Description.—The mackerel sharks (this and the two species following) are easily told from all the sharks so far mentioned by the shape of the tail, for while its lower lobe is sharklike, somewhat smaller than the upper, the difference is slight, the tail being almost evenly forked, with the upper lobe directed so sharply upward, the lower downward, that the tail as a whole is crescentic and much broader than long. In fact it recalls the tails of such pelagic bony fishes as the mackerel tribe or the swordfish in outline, likewise in its firm texture. More precise if less obvious a character is that the root of the tail bears a well marked longitudinal ridge or keel on either side, a feature shared by the white and basking sharks (pp. 39 and 41).

This is a stout, heavy-shouldered shark, tapering in front to a sharply pointed snout and behind to a very slim tail root. Its dorsal and pectoral fins are very large; the former, originating over the armpit of the pectoral, is triangular and about as high as long; the latter, broad-based but tapering sicklelike to a narrow tip,

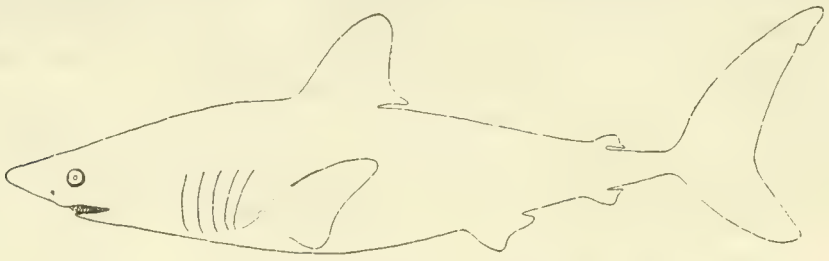

Fig. 12.—Mackerel shark (*Isurus punctatus*). After Garman

is only about half as broad as long. The second dorsal and anal fins are very small indeed, and the ventrals but little larger. The second dorsal stands over the anal. The positions of the dorsal fins are the readiest field mark to distinguish this species from the sharp-nosed mackerel shark (p. 38). The teeth are alike in the two jaws—small, slender, pointed, smooth-edged, and without spurs on the sides—and their structure differentiates this shark from the European porbeagle (*Isurus nasus*), which it otherwise resembles closely but in which the teeth bear a sharp denticle on either side at the base of the cusp.

Size.—The larger mackerel sharks are usually about 8 to 10 feet long, growing to an extreme length of about 12 feet.

Color.—The upper parts are dark bluish gray to bluish brown, changing abruptly to white below. According to Garman the dorsal, pectoral, and tail fins are tipped with black, there is a black area in the armpit of the pectoral followed by a white space on the fin and body, and there is a large and very noticeable black spot on the outer half of the pectoral, which is one of the distinguishing features of this species.

General range.—North Atlantic and Pacific Oceans. Closely allied to the ommon porbeagle (*Isurus nasus* Bonaterre) of British seas.

Occurrence in the Gulf of Maine.—From the days of the earliest settlement it has been known that stout-shouldered, surface-swimming sharks of moderate size and with "mackerel" tails are tolerably common in the Gulf of Maine, universally referred to by the fishing population as "mackerel sharks." During the first half of the last century only one such shark species was recognized in our waters, but more recent researches have proved that there are actually two—the present one and the next—readily separable by the position of the first dorsal fin relative to the pectorals and of the second dorsal relative to the anal, but so much alike in general appearance that it is usually impossible to determine without actually examining the specimens to which species many of the records actually belong. However, since *I. punctatus* is the more northerly of the pair, and since far more specimens of it than of *I. tigris* have actually come to hand, probably most of the mackerel sharks that fisherman so often see swimming lazily on the surface off the shores of Northern New England belong here.

Although these sharks are far more often seen than captured, we have definite record of the common mackerel shark at Provincetown, in Massachusetts Bay, off Cape Ann, and at various localities along the Maine coast—e. g., off Cape Elizabeth, in Casco Bay, off Monhegan, and even Passamaquoddy Bay in the Bay of Fundy, where, however, Huntsman (1922a) records but a single specimen. During our *Grampus* cruises we have seen many mackerel sharks, particularly between Cape Ann and the Isles of Shoals, and off Monhegan Island. This shark likewise ranges northward along the Nova Scotian coast and into the Gulf of St. Lawrence. It may, in fact, be described as common, if not abundant, and to be expected anywhere in the Gulf of Maine during the summer. In winter it apparently departs (no doubt for warmer seas), and it is during its southward journey throughout autumn and up to the end of November that mackerel sharks are commonest in the Woods Hole region, while at Nantucket they (or the next species) are commonest in spring when they are taken in the mackerel drift nets. As yet our knowledge of the migrations of this shark into and out of the Gulf of Maine is of the haziest. Certainly, however, it visits us in greater or less number annually, and is most numerous when mackerel are plentiful.

Habits.—The whole mackerel-shark tribe, as contrasted with the ground sharks, are strong, active swimmers, leading a pelagic life near the surface of the high seas, wandering about over the ocean in pursuit of the fishes on which they prey, and often uniting in small companies, though they can hardly be called gregarious. Like swordfish they spend much time at the surface on calm days, when their triangular back fins, followed by the tip of the caudal fin (the bluntness of the former and the wavy track of the latter identify the shark as such) may often be seen cutting through the water. Again and again we have sailed up on sharks probably of this species, only to see them sound, just out of harpoon range, plainly visible at first but soon fading from sight as they swim downward with undulating motion. This is a viviparous species. In the Gulf of Maine gravid females, each carrying a pair of young, have been taken in winter.[26]

[26] Kendall, 1914, p. 186.

Food.—The mackerel shark feeds on small fish, especially on mackerel and no doubt also on herring (which are an important article in the diet of its European congener) as well as on such other schooling fishes as shad and menhaden. It is also known to eat hake and squid. We find no record of its eating Crustacea, nor do fishermen report it as doing so.

Commercial importance.—At the present time the mackerel shark is not of any practical value in the Gulf of Maine. On the contrary it is often a serious nuisance from its habit of rolling itself up in an inextricable snarl of twine when it entangles itself in drift or gill nets. Many years ago shark oil was prized by curriers, and the livers of this species were tried out in considerable quantity, but this was never more than a minor industry, abandoned before the middle of the past century. It is interesting to read, however, that as much as 11 gallons of oil have been obtained from the liver of a single shark 9 feet long, and report has it that the richness of the livers in oil fluctuates over periods of years.

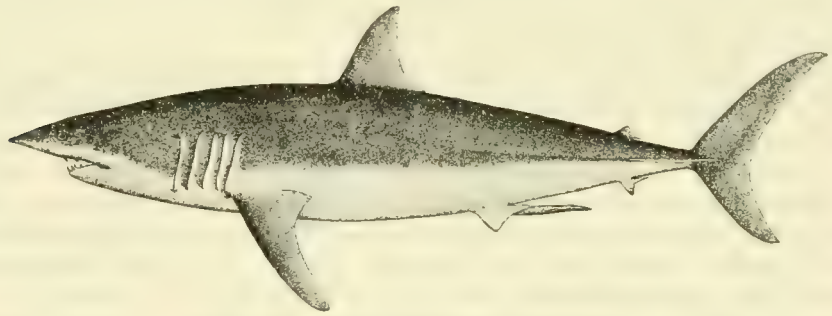

FIG. 13.—Sharp-nosed mackerel shark (*Isurus tigris*)

12. **Sharp-nosed mackerel shark** (*Isurus tigris* Atwood)

Jordan and Evermann (*Isurus dekayi* Gill), 1896–1900, p. 48.
Garman, 1913, p. 36.

Description.—This shark so closely resembles the common mackerel shark that I need merely point out the points of difference. Most obvious of these is that while in the latter the first dorsal originates above the armpit of the pectoral, in *I. tigris* it stands altogether behind the inner corner of the latter, and the second dorsal originates a short distance in front of the anal. Its snout, likewise, is sharper, its pectorals narrower, and there is a color difference.

Size.—About the same size as the porbeagle; that is, growing to a maximum length of about 10 feet.

Color.—Dark bluish-gray or bluish to ashy brown above, white below, and without the black spot on the pectoral fin so characteristic of the common mackerel shark.

General range.—Gulf of Maine to the West Indies.

Occurrence in the Gulf of Maine.—As I have pointed out above, there is no knowing how many of the "mackerel sharks" reported by fishermen in the Gulf of Maine may actually belong to this and not to the preceding species. However, not only is it nowhere common so far as known, but its center of abundance seems to be

south of Cape Cod. The only definite Gulf of Maine records for it, so far as we can learn, are as follows: Off Seguin Island, Casco Bay, Provincetown, Cape Cod, and Massachusetts Bay. We have not seen it. It has been netted in Vineyard Sound as late in the season as December, and occurs as far south as the Gulf of Mexico. On the other hand it is known to wander as far north as Maine.

Habits and food.—This shark is a more slender fish than the common mackerel shark—large, powerful, and swift-swimming, feeding upon small fish and squid. Little is known of its habits, though what has been written of its relative, *I. punctatus*, probably applies equally to *I. tigris*. Its breeding habits are not known.

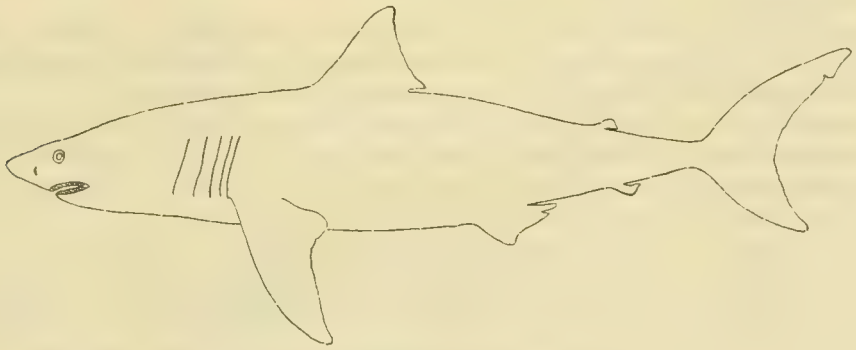

FIG. 14.—White shark (*Carcharodon carcharias*)

13. White shark (*Carcharodon carcharias* Linnæus)

MAN-EATER SHARK

Jordan and Evermann, 1896–1900, p. 50.
Garman, 1913, p. 32.

Description.—The white shark is of the general "mackerel shark" appearance, with firm lunate tail, the upper lobe only slightly longer than the lower, triangular first dorsal of moderate size originating over the armpits of the pectorals, which are sickle shaped, and roughly twice as long as broad. The second dorsal and anal fins are very small, and the root of the tail bears a well-marked keel on either side. The snout is pointed. Unfortunately there is no obvious "field mark" to distinguish a small white shark from the common mackerel shark when seen swimming, for while the former is the slimmer fish the difference in form is not great. Once captured, however, no confusion could arise, for instead of the slim catlike teeth of the porbeagle we find the man-eater best armed of all modern sharks, its teeth large and triangular and similar in shape in the two jaws though broadest in the upper, with nearly straight cutting edges and serrated margins. As a precaution, however, any *very* large, active shark, upwards of 18 feet (3 fathoms) long, with the tail *not* long (out of ordinary proportions) should be looked upon with suspicion—it *might* prove to be a man-eater. If it were sluggish, resting with the dorsal fin high out of water, it would no doubt be a harmless basking shark (p. 41).

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Size.—This is one of the largest sharks, growing, it is said, to a length of 40 feet or even more. In the British Museum there are the jaws of a specimen 36 feet long. In a shark as large as this the teeth are about 3 inches long. A white shark 12 feet 8 inches long, taken near Woods Hole, was estimated to weigh 1,000 pounds.

Color.—Back slaty or leaden gray, shading gradually to the white of the under parts. In the porbeagle the transition on the sides from dark back to pale belly is more sudden. There is a black spot in the armpit of the pectoral fin, but neighboring parts of fin and body are white. Dorsal, pectoral, and caudal fins are darkest at their rear margins, but the ventrals are darkest (olive) along the forward edge, fading rearward to white.

General range.—Cosmopolitan in tropical and warm-temperate seas, straying northward at rare intervals as far as New England and casually to Banquereau Bank off eastern Nova Scotia.[27] It is apparently rare everywhere.

Occurrence in the Gulf of Maine.—The only reliable Gulf of Maine records of this ill-omened shark are of two small ones mentioned by Storer as taken by Massachusetts fishermen between 1820 and 1850; one about 13 feet in length and weighing about 1,500 pounds, killed at Provincetown in June, 1848, which he described under the name *C. atwoodi*; another captured at Eastport, Me., in 1872; one 7 feet 2½ inches long taken many years ago in Massachusetts Bay (figured by Garman, Memoirs, Museum of Comparative Zoology of Harvard University, Vol. XXXVI, 1913, pl. 5, figs. 5–9); and one 16 feet long, taken in a trap at East Brewster, Mass., October 16, 1923, and identified by Doctor Garman. Captain Atwood[28] also writes that he saw four caught in mackerel nets at Provincetown. Several more (all rather small) have been taken at Woods Hole in the fish traps, and one off South Amboy, N. J., on July 14, 1916.

So seldom does this tropical shark stray to the Gulf of Maine that it would deserve no more than the briefest mention were it not the only shark likely to attack human beings. Being equipped as it is with a most terribly effective set of cutting teeth, and strong and active, the white shark has borne an unsavory reputation as a man-eater from the earliest times, and it was probably a small "man-eater"—in fact, the specimen listed above from South Amboy—that was responsible for the shark fatalities along the New Jersey beach in July, 1916 (p. 22). Hence, so long as white sharks do occasionally wander within our limits the possibility of similar attacks on bathers along beaches of Massachusetts is always open, if exceedingly remote. So far as we can learn, however, there is no actual record of a white shark wantonly attacking human beings in the Gulf (p. 22), but Captain Atwood tells us of a case where a rather small one (apparently the 13-foot specimen described by Storer) turned furiously on a boat but was eventually lanced to death and brought into Provincetown. It is on record, also, that one about 13 feet long attacked a fisherman in a dory on Banquereau Bank many years ago, leaving in the sides of the boat fragments of its teeth, by means of which Doctor Garman was able to identify the species to which the shark belonged.[29]

[27] Putnam. Bulletin, Essex Institute, vol. 6, 1874, p. 72. Salem.
[28] Quoted, by Goode et al, 1884, p. 671.
[29] Putnam. Bulletin, Essex Institute, vol. 6, 1874, p. 72.

Habits and food.—So rare (and fortunately so) is this shark even in the tropics that practically nothing is known of its habits. It feeds on large fish, on sea turtles, and perhaps on porpoises. Off the California coast sea lions also fall prey to it—vide Jordan and Evermann's account of a young sea lion of 100 pounds weight in the stomach of a 30-foot white shark. As to its breeding habits nothing is known, though presumably it is viviparous like its close relatives.

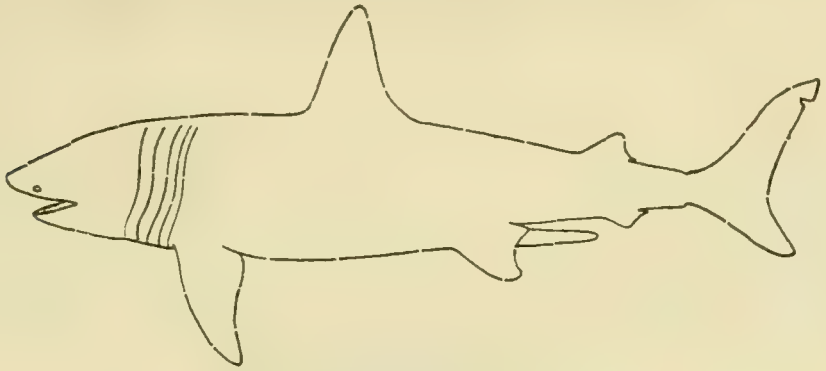

FIG. 15.—Basking shark (*Cetorhinus maximus*)

14. **Basking shark** (*Cetorhinus maximus* Gunner)

BONE SHARK

Jordan and Evermann, 1896–1900, p. 51.
Garman, 1913, p. 39.

Description.—The basking shark resembles the other mackerel sharks in its lunate tail, which is much broader than long and with the lower lobe but little shorter than the upper; in the presence of a strong "fore and aft" keel on either side of the root of the tail; in the fact that the second dorsal fin is very much smaller than the first; and in its form, tapering in both directions to snout and tail. However, it is set apart from all other sharks by the enormously long gill slits, which extend nearly right around the neck, and—even more significant—that alone of all its tribe, except its relative the whale shark (Rhinodon), it has rakers on its gill arches, suggesting (though not corresponding to) those of herring, menhaden, etc., among bony fishes. It was the fancied resemblance of these rakers to the whalebone of the whalebone whales that suggested the vernacular name "bone shark" to the whalemen of olden times.

Corresponding to its feeding habits, the mouth of the basking shark is very large, but its teeth are very small though numerous. I need only note further that the triangular first dorsal fin stands midway between pectorals and ventrals, and though the back fin is little longer in proportion than that of the other mackerel sharks it rises high in the air when the fish lies awash on the surface, as is its habit—a valuable field mark (p. 39). The nose of large specimens is of ordinary "shark" outline—short, conical, bluntly pointed. In young fish, however, up to 12 or 13 feet in length, it is curiously contracted in front of the mouth into a semicylindrical snout pointed at the tip.

Size.—The basking shark grows to a length of at least 45 feet, perhaps larger. Several specimens 28 to 35 feet in length have been recorded from the New England coast, and still larger ones have been reported, but on doubtful evidence.

Color.—This shark is grayish-brown, slaty, or nearly black above. The under parts are usually described as white, but the Menemsha specimen recorded by Allen [30] was of a lighter shade of slate below than above, and one 14 feet long captured at West Hampton, Long Island, on June 29, 1915,[31] had the belly as dark as the back, the only white being a patch underneath the snout in front of the mouth.

General range.—This enormous fish is usually said to be native to Arctic seas, straying southward to Portugal on the one side of the Atlantic, to Virginia on the other side, and to California in the North Pacific. It would, we think, be more accurate to say that it roams the whole North Atlantic from latitude about 35° north to Iceland and northern Norway, Smitt [32] having shown that it is not, strictly speaking, an Arctic fish, and that the old tales of a tremendous whale-eating shark, on which Fabricius based his statement that the basking shark occurs in Greenland seas, were false. It is also plentiful enough off the coasts of Ecuador and Peru in the South Pacific to support a considerable local fishery.[33]

Occurrence in the Gulf of Maine.—Of recent years the bone shark has been seen but seldom in the Gulf of Maine, the list being as follows: One 28 feet long was killed in Maine waters in 1828; one off Musquash Harbor in the Bay of Fundy in August, 1851; one of 34 feet at Eastport in 1839; several ranging in length from 25 to 35 feet, killed there in 1868 and 1870; a considerable number seen and several secured off Cape Elizabeth in 1848 by a whaler cruising for humpback whales; one of 35 to 38 feet harpooned but lost between Boston and Provincetown in 1864; and one killed near Provincetown in 1835, another in 1836 or 1837, a third in 1839, and a fourth in 1847. We do not find another definite record of the bone shark in the Gulf of Maine until October 8, 1908, when one 18 feet long (measured by J. Henry Blake) was taken in a weir near Provincetown. Two more have been killed there since—one a 22-foot fish on October 9, 1909, and the other of 29 feet on June 8, 1913, both in the harbor. Mr. Blake also reported one of 31 feet (16 feet in girth) as taken at Long Point, near by, but the year is not recorded. A small one of 12 to 14 feet was caught at Menemsha Bight on Marthas Vineyard on August 16, 1916, and one of about 26 feet 6 inches [34] at the same locality on June 24, 1920. The bone shark is so large a fish and so conspicuous, thanks to its basking on the surface, that every specimen visiting the coastwise waters of the Gulf is almost certain to be seen sooner or later and to be harpooned. Hence it is probably no commoner there than the meager record suggests.

[30] Bulletin, Boston Society of Natural History, No. 24, March, 1921, p. 5.

[31] This specimen is described by Hussakof (Copeia, Aug. 24, 1915, No. 21, pp. 25–27).

[32] Scandinavian Fishes, 1892, p. 1146.

[33] This fishery is described by Stevensen (Report, U. S. Commissioner of Fisheries for 1902 (1904), p. 228).

[34] This specimen is now preserved, mounted, in the Boston Society of Natural History, and described by Allen (Bulletin, Boston Society of Natural History, No. 24, March, 1921, pp. 3–10), who collected the foregoing records.

Before the coming of the white man this great shark seems to have been a regular inhabitant of the Gulf of Maine, which afforded it an excellent pasture, for old tradition has it that large numbers were taken in Massachusetts waters for their oil during the first half of the eighteenth century. However, the local stock soon went the same way as the local stock of the North Atlantic right whale—into the try pot—and this seems also to have been its fate in Norwegian waters, where it was sufficiently abundant to support a regular fishery up until about 1820, since which time it has been killed down to but a fraction of its former numbers. Indeed, the basking shark to-day is something of a rarity off the coast of Norway, but in other parts of the world, particularly in Icelandic waters, off Ireland, and off Peru, as noted elsewhere (p. 42), it is still moderately plentiful.

Habits.—This is a sluggish, perfectly inoffensive fish, helpless of attack so far as its minute teeth are concerned, and spending much time sunning itself on the surface of the water, often lying with its back awash, on its side, or even on its back, and sometimes loafing along with the snout out of water. Hardly a writer mentioning this shark but tells us that two or three swimming tandem, with the dorsal fins high in the air, are the basis for "sea-serpent" myths. At times bone sharks are gregarious, traveling together in schools. Nothing whatever is known of the breeding habits of the basking shark.

Food.—Next to its vast bulk and its curiously sluggish habit, the most interesting peculiarity of the basking shark is its diet, for it subsists wholly on minute Crustacea, particularly on copepods, and on other tiny pelagic animals, which it sifts out of the water by means of its greatly developed gill rakers, exactly as do such plankton feeders as menhaden on the one hand and whalebone whales with their baleen sieves on the other.

Commercial importance.—Although the day of the bone shark in New England waters is long past, probably never to return, it may be of interest to point out that it has always been hunted whenever encountered by the sperm whalers from New Bedford, and that it is still an object of pursuit off the coasts of Iceland and Ireland. It was and is valued solely for its liver oil, individual fish as a rule yielding from 80 to 200 gallons (average about 125 gallons), with as much as 400 gallons from a single liver not unheard of and a yield of 600 gallons reported. The basking-shark fishery has always been carried on with harpoons, the shark being quite indifferent to the approach of a boat though it swims actively and strongly when struck. Fat ones are subdued more easily than lean ones.

THE SPINY DOGFISHES. FAMILY SQUALIDÆ

This group is characterized and made easily recognizable by the presence of two dorsal fins, each with a fixed spine, but no anal fin, while the teeth are alike in the two jaws in some, unlike in others.

15. Spiny dogfish (*Squalus acanthias* Linnæus)

DOGFISH; PIKED DOGFISH; GRAYFISH

Jordan and Evermann, 1896–1900, p. 54.
Garman, 1913, p. 192.

Description.—So rare are all other spiny sharks in the Gulf of Maine that any little shark with a large sharp spine close in front of each dorsal fin caught there is practically sure to be a "dog," of which there are thousands in the Gulf to one of any other shark. Should the fish be uniform dark brown or black it might possibly (but not probably) prove to be the black dogfish (p. 52). A glance at the tail fin will settle the question, for the rear margin of the latter is deeply notched near its tip (fig. 19), whereas in the common spiny dog its margin is entire.

This is a slender little shark with tapering but rounded head and flattened snout. Its first dorsal fin stands between pectoral and ventral; its second dorsal is about

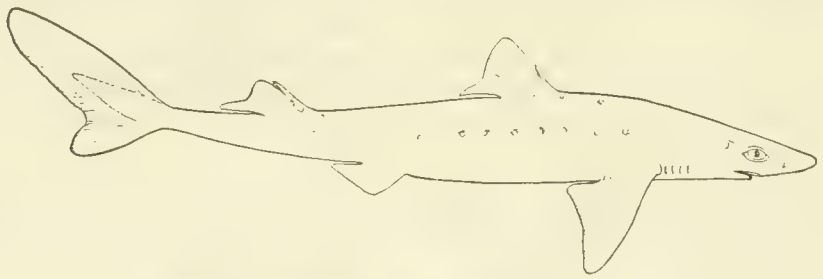

FIG. 16.—Spiny dogfish (*Squalus acanthias*). After Garman

two-thirds as large as the first; its pectoral is triangular, broader at the base than it is long; the lower lobe of the tail fin is well marked; and the ventrals are well forward of the second dorsal. The spines are close up against the front margins of the two dorsals, the first shorter and the second nearly as long as their respective fins are high, and they are very sharp, as every fisherman knows to his cost. The spiny dog has no anal fin, a lack separating it from all smooth-finned sharks known from the Gulf of Maine, except the Greenland shark (p. 53). There is a low fold of skin on either side of the root of the tail back of the second dorsal fin, so small, however, that there is no danger of confusing it with the keels of the mackerel sharks. The teeth are small, their sharp points bent toward the outer corners of the mouth and each row forming a continuous cutting edge.

Size.—Mature dogs are ordinarily 2 to 3½ feet long. Mature males grow to a length of about 3 feet and a weight of 5 to 6 pounds; females to 3 or 3½ feet and a weight of 8 pounds. Occasionally very large fat specimens may reach a weight of 15 pounds.

Color.—Usually slate colored above but sometimes brown, with a row of small white spots on each side from the pectoral to abreast of the anal, and a few other white spots in front of and behind the first dorsal and in front of the second dorsal fins. These spots are most conspicuous in small fish up to 12 or 14 inches in length and fade with growth until in some specimens they disappear altogether. It is gray to white below.

General range.—Both sides of the North Atlantic, also Mediterranean; on the American coast from the Gulf of St. Lawrence and the banks of Newfoundland south to Cuba. Replaced by closely allied species in the North and South Pacific and Indian Oceans.

Occurrence in the Gulf of Maine.—The spiny dogfish—"dogfish" or "dog" in common parlance—makes up for the comparative rarity of other sharks in the Gulf of Maine by its obnoxious abundance. To mention all the localities from which it has been reported there would be simply to list every seaside village and every fishing ground from Cape Cod to Cape Sable. On the offshore banks, too, it is as familiar as it is along the coast. Dogfish are seasonal visitors. In spring they strike in almost simultaneously along the whole coast from New England to North Carolina, appearing at Cape Lookout in April, off Long Island abundantly in May, and as early in the season on Georges Bank (April–May) as at Cape Lookout. In the inner parts of the Gulf of Maine the date of the first heavy run of dogfish varies widely from year to year and from place to place. We have not heard of them in Massachusetts Bay before May. Indeed, summer warming is hardly appreciable more than a few fathoms below the surface until well into that month, so they could hardly be expected earlier. However, according to reports of local fishermen the period of freedom may close there as early as the last half of the month in some years. In 1903, for example, they appeared as far north as Penobscot Bay by the middle of May, and though as a rule it is not until June that they arrive in numbers in the Massachusetts Bay region, it is sometimes impossible to set gill or drift nets anywhere between Cape Cod and Cape Elizabeth after the first days of that month, so numerous are they. In 1913 the first heavy run of dogs struck Ipswich Bay on June 14, and they appeared there at about the same date in 1905, but there is much local variation in this respect. In 1903, for example, they did not appear until early July at Provincetown, though swarming a month earlier in other parts of Massachusetts Bay, in Ipswich Bay, and off Penobscot Bay. However, they usually strike in all along the northern Maine and west Nova Scotian coasts by the end of June, though earlier in the open Bay of Fundy than in Passamaquoddy Bay, where few are seen until late in July.

West of Cape Cod (that is, at Woods Hole and off Long Island) it was formerly believed that these little sharks were only transients, passing north in spring, south in autumn, which were the only seasons when they were seen inshore regularly. However, dogs, both large and small, are caught in the traps of the Woods Hole region in July, and Latham's [35] recent discovery that adult spiny dogfish are common in deep water in Long Island Sound in summer, together with the fact (on which he comments) that young ones are taken in great numbers in the traps on Long Island

[35] Copeia, Oct. 15, 1921, No. 99, p. 72.

in July and August, is sufficient proof that while some of the fish that visit the middle Atlantic coast in spring may go north to the Gulf of Maine, others merely drop down into deeper water to summer, coming inshore again for a time in autumn.

Most of the dogfish take their departure from the inner parts of the Gulf during October, few being caught on the coast north of Massachusetts Bay after November 1. Rarely, however, they stay later, as in 1903 (a big dogfish year), when they were abundant along the outer shore of Cape Cod as late as the third of the month. Ordinarily none are caught within the Gulf of Maine north of Georges Bank in winter, but this, like most rules, has its exceptions. In 1882, for example, schools

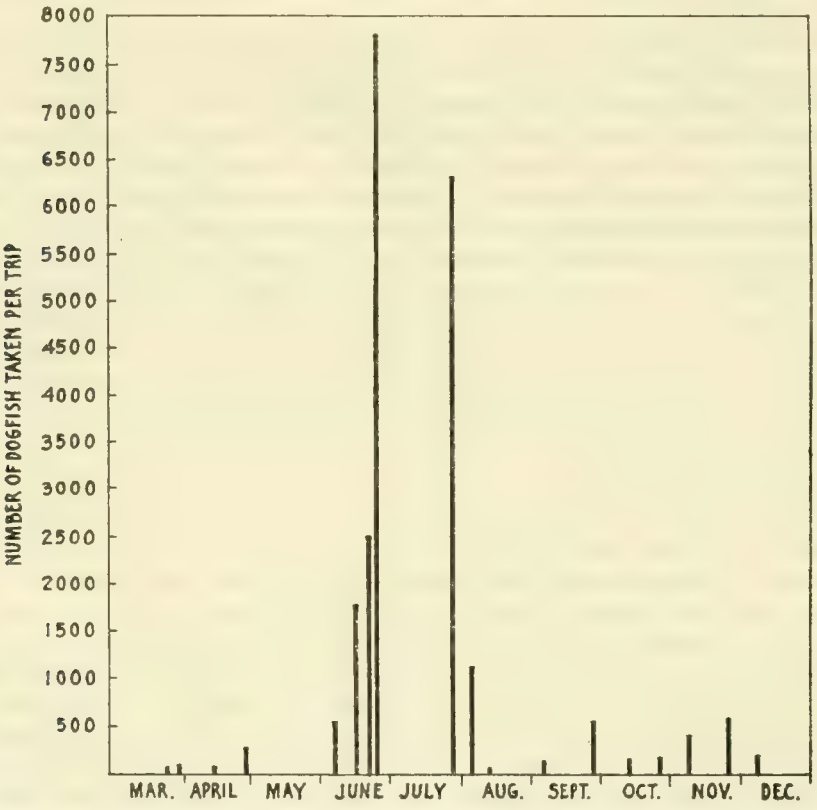

FIG. 17.—Numbers of spiny dogfish caught on certain otter-trawling trips to Georges Bank during the different months of 1913

were reported off Portsmouth in February, while in 1913 a few were caught 20 miles off Cape Ann on November 19 to 24, many near Boon Island from December 5 to 13, and on Jeffrey's Ledge on December 11 and 12.

Dogfish appear earlier in spring and linger later into the winter on Georges Bank (fig. 17) than in the inner parts of the Gulf. It is safe to say that there are few there in March, the earliest definite record (obtained during the investigations of 1913) being of 25 fish caught on the "winter cod ground" east of the shoals (longitude about 67°, latitude about 41° 40′) between the 20th and the 22d, and of 46 from the same general region from the 27th to the 30th. Their numbers

increase rapidly in April on Georges Bank, however, and they are a pest there after the 1st of May, while the last half of June, July, and August sees them at the height of abundance at least on the portions of the bank resorted to by the otter trawlers at that season. Whether by chance or as reflecting an actual diminution in the stock of dogfish present, the catches fell off markedly during September in 1913, but considerable numbers were taken throughout that month. Very few were actually captured by the trawlers in October, but there was a considerable increase in November, probably reflecting the southward passage of the schools that had spent the summer further east. A few were caught in November and December, and one on the southern part of the bank (latitude about 41°, longitude about 67° 30′) as late as January 20 to 22. Thus February is the only month when the bank is entirely free of them. The time table just outlined for the year 1913 may be taken as typical, for it corroborates the various reports of fishermen tabulated by the Massachusetts Commissioners of Fisheries and Game in 1905. Apparently dogfish reach Browns Bank rather later than they do Georges, for none were taken there on April 14 in 1913, though they are only too plentiful there in summer. It is also very likely that they depart thence rather earlier, though a few lingered as late as December 3 to 12 on Western Bank off Halifax in that year. Gravid females have been described as arriving before the males in spring, but this remains to be confirmed.

The accompanying graph (fig. 17) of the numbers of dogs taken by certain otter trawlers on Georges Bank at various dates during the year 1913 will more graphically illustrate the seasonal fluctuations of this fish there, with the reservation that the precise catches are governed not only by the abundance of the stock but also by the precise grounds fished on and by the general success of the sets.

The winter home of the Gulf of Maine dogfish is still to be learned. They have often been said to migrate south to the Tropics, and it is certain that some dogfish do reach Cuba during the cold season, but the fact that they appear so nearly simultaneously all along the coast north of North Carolina in spring, and that they leave Georges Bank so late in the season, with the discovery of dogfish in deep water in Long Island Sound in summer (p. 45) argues for an on-and-off rather than a longshore migration, with the deep water off the continental slope as their winter home. This is corroborated by the fact that on February 20 to 21, 1920, the *Albatross* trawled several specimens in depths of 90 and 199 fathoms along the continental edge off Chincoteague, Va., and off Delaware Bay. Also, they are usually so thin when they appear in spring that they can feed but little during the winter. In short, evidence is gradually accumulating to the effect that the seasonal movements of the spiny dogfish parallel those of the mackerel (p. 191).

It is generally believed that dogfish not only summer more regularly in the region of Massachusetts Bay now than of old, but that they are far more numerous there than during the first half of the past century. At Woods Hole, on the contrary, they and the smooth dogfish were much more plentiful before 1887 than at any time since then. To a certain extent, of course, reports of fluctuations in abundance from year to year must be discounted as reflecting the movements

of the great schools that may visit one part of the coast one summer and another part the next, there being no general alteration of the stock, but the many fishermen who reported to the Massachusetts Commissioners in 1905 were so unanimously of the opinion that dogfish had multiplied steadily for 20 to 30 years past as to point unmistakably to the conclusion that the species as a whole was then in one of the periodic upswings characteristic of various other fishes. Reports from British coasts are to the same effect. Perhaps the years 1904–5 marked the apex of this wave of multiplication; at any rate dogfish were reported as distinctly less troublesome to the mackerel netters in 1913 than in previous years, and since that time less complaint has been made of them, though it is too soon to say whether a general diminution of the stock is actually in progress.

Much has been written of the habits of the spiny dogfish, all to the effect that it has nothing to recommend it from the standpoint either of the fishermen or of its fellow creatures in the sea. It is one of the more gregarious of our fishes, swimming in schools or packs. Swedish fishermen assert that young dogs school separately from their parents, and it is certain that fish of a size continue to associate together as they grow, the result being that any given school runs very even, consisting as a rule either of the very large mature females, of medium-sized fish (either mature males or immature females), or of small immature fish of both sexes in about equal numbers.[36]

Apart from its general seasonal migratory movements, the dogfish are governed by the movements of the fishes on which they prey and in pursuit of which they roam about, striking in here and there in multitudes. Fortunately they seldom stay long in one place, but there is seldom, if ever, a time during the summer when they are not common on some part of the Gulf of Maine coast. So erratic are their appearances and disappearances that where one has good fishing to-day he may catch only dogfish to-morrow and nothing at all the day after, the better fish having fled these sea wolves and the latter departing in pursuit.

The dogfish use their back spines for defense, curling around in a bow and striking, which makes them hard to handle on the hook. It is probable, too, that the spines are slightly poisonous, general report to this effect being corroborated by the fact that the concave surfaces are lined with a glandular tissue resembling the poison glands of the venomous "weever" (*Trachinus draco*).[37]

Strong, swift-swimming, voracious almost beyond belief, the dogfish entirely deserves its bad reputation. Not only does it harry and drive off mackerel, herring, and even fish as large as cod and haddock, but it destroys vast numbers of them. Again and again fishermen have described the sight of packs of dogs dashing among schools of mackerel, and even attacking them within the seines, biting through the net, ruining the gear, and releasing such of the catch as escapes them. Often, too, they bite groundfish from the hooks of long lines, take the baits and make it vain to fish where they abound. In Massachusetts and Ipswich Bays,

[36] Ford (Journal of the Marine Biological Association of the United Kingdom, new series, Vol. XII, No. 3, Sept., 1921, pp. 468–505, Plymouth, England) has recently published very interesting notes on this and other phases of the life-history of the spiny dogfish, with a summary of the earlier statements as to the breeding season.

[37] Dale (Philosophical Transactions, Royal Society of London, series B, Vol. 212, 1923, p. 27) describes the spines and gives clinical records of the effects of wounds inflicted by them.

indeed, as well as about the Isles of Shoals, hook-and-line fishing is often actually prevented during the period of summer plenty unless cockles be used for bait, for dogfish do not take these. When schools of dogfish rush headlong into net or seine, as often happens, they so snarl the twines that disentanglement and repair may be the work of days, and it has been estimated that they do no less than $400,000 worth of damage annually to fishing gear and to fish caught by such gear off the Massachusetts coast alone—probably no less along the shores of Maine, so that in the aggregate they are a heavy debit in the economic scale. Rumor has it, even, that packs of dogfish have been known to attack swimmers and literally bite them to pieces, but we can not vouch for this. At one time or another they prey on practically all species of Gulf of Maine fish smaller than themselves, and squid are also a regular article of diet whenever they are found. Dogfish are also known to take worms, shrimps, prawns, and crabs, and when they first arrive at Woods Hole from the south in May they are often found full of Ctenophores, being one of the few fish that eat these watery organisms. It would be pure guesswork to attempt to estimate the actual numerical strength of the dogfish, but they must be plentiful, indeed, when they can often be caught as fast as they can be hauled in, when line trawls with 1,500 hooks have brought in a dogfish on nearly every hook, and when as many as 20,000 have been recorded in a single draught of a seine in British waters.

Breeding habits.—From time immemorial fishermen have known that the spiny dogfish is viviparous. Aristotle, indeed, describes its manner of bearing young. The eggs are large, well stored with yolk, and during early stages of development those in each oviduct (the so-called "uterus") are contained in a horny capsule that later breaks down, leaving the embryos lying free in the "uterus" with which they have no placental attachment. Ford's studies, mentioned above, suggest about 10 to 11 months as the period from fertilization to birth, which takes place when the young are 9 to 12 inches (23 to 31 cm.) long, and as they are then practically of adult form with the yolk almost wholly absorbed, strong and active, their chance of survival is excellent. Ordinarily a female has 3 or 4 young to a litter—sometimes as few as 1 or as many as 8 to 11—and while the embryos are developing in the uteri a fresh set of ovarian eggs is growing, ready to take their place. It has often been suggested that the dogfish may give birth to 2 or 3 litters—that is, upwards of 20 pups—annually, but if Ford's estimate of the duration of gestation is correct one litter per year would be the rule. Statements as to the season at which the young are born are conflicting. At Plymouth, England, this takes place from January until March, according to Garstang; from August until December, according to Ford. This, of course, suggests two distinct breeding seasons, and we believe that, similarly, among the dogfish that visit the Gulf of Maine some females give birth to their young in late autumn, others in late winter or early spring. For the evidence on which we base this view we are indebted to Dr. H. V. Neal, whose acquaintance with dogfish on the Maine coast is very intimate. It has long been known that when the dogs first appear on the Massachusetts coast in May or June many of the females contain embryos

of some size, which, as Doctor Neal tells us, grow to 4 to 7 inches in length by July. However, during this same month other females caught along the coast of Maine are found to contain embryos in very early stages of development, from the formation of the germ ring to a length of about 4 mm. By September the embryos of the older generation range from 7 to 11 inches in length, some of them being almost ready to be born, while those of the younger generation (any given female contains only embryos of one or of the other generation, never of both) have grown to an average of about 17 mm. Probably the older generation is born in October and November, while the younger one winters in the uterus of the mother, to be born in spring. Fall-bearing females are then fertilized again, the development of the next set of eggs commencing in the early winter, while spring-bearers are fertilized in early summer, which corroborates 11 months as the known period of gestation (p. 49). This would also explain the fact that dogfish smaller than a foot in length are never reported in the Gulf of Maine, for the young are produced during the season when there are very few dogs on this coast, these few probably being immature. In short, the inner parts of the Gulf of Maine probably do not serve as a nursery for the dogfish, plentiful though this fish is there in summer, but the young are born somewhere offshore and probably while the parents are in deep water. It seems, however, that this seasonal schedule does not apply west of Cape Cod, for Latham[38] records a great abundance of very young ones taken in the traps in Long Island Sound in August, showing that one generation is produced there in midsummer. Dogfish only 1 foot long, hence new born, have been found in the stomach of a goosefish at Woods Hole in July (p. 527).

Commercial value.—With the dogfish so destructive to fish and to gear, and with so many of them caught both by lines and by otter trawls during more than half the year, it is no wonder that serious efforts have been made to utilize them on a large scale—to make them marketable and a source of revenue instead of a dead loss. Since this matter has been the subject of discussion elsewhere we need point out only that the dog is a far better food fish when fresh than is generally appreciated, and that it would offer a tremendous supply of cheap food were a satisfactory method of canning it to be worked out. Dogfish have also been used in the manufacture of fertilizer, and enough dogfish livers are brought into New England fishing ports to yield almost 10,000 gallons of oil annually, which is combined and sold with cod-liver oil. Up to the present, however, dogfish have not been of sufficient value to compensate for a hundredth part of the damage they do and most of those caught are thrown back into the sea.[39]

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[38] Copeia, Oct. 15, 1921, No. 99, p. 72.

[39] For further discussion of the damage done by dogfish and of their commercial possibilities, see the following: "Report upon the damage done by dogfish in the fisheries of Massachusetts," Annual Report, Commissioners of Fisheries and Game [of Massachusetts] for 1905 (1906), pp. 97–169; "Aquatic products in arts and industries," by Charles H. Stevenson. Report of the Commissioner, U. S. Commission of Fish and Fisheries, Part XXVIII, 1902 (1904), pp. 228–229; Field, 1907, pp. 12–18, 40–49; "Sea mussels and dogfish as food," by Irving A. Field. Proceedings of the Fourth International Fishery Congress. *In* Bulletin, U. S. Bureau of Fisheries, Vol. XXVIII. 1908 (1910), pp. 243–257; and Mavor, 1921, pp. 125–135.

16. **Portuguese shark** (*Centroscymnus cœlolepis* Bocage and Capello)

Jordan and Evermann, 1896–1900, p. 55.
Garman, 1913, p. 204.

Description.—This shark can easily be identified by the fact that while its general appearance—particularly the absence of anal fin, the situation of the ventrals far back under the second dorsal, and its rather stout form and blunt snout—might lead a hasty observer to think he had caught a small Greenland shark, more careful examination, by touch if not by eye, would reveal a short spine close in front of each dorsal fin. The first dorsal is smaller than in any of our sharks except the "Greenland," the second is about as high as the first, and the ventrals are larger than either. The tail is notably short and broad and its upper lobe is notched. The teeth are very different in the two jaws—narrow, pointed, and of the seizing type in the upper; broader, oblong, with a notch on one side near the tip, and forming a cutting edge in the lower.

Size.—Adults run from 3 to 4 feet long, as they are caught. Garman records one 44 inches long off the coast of New England, but 10 inches is the smallest we find mentioned.

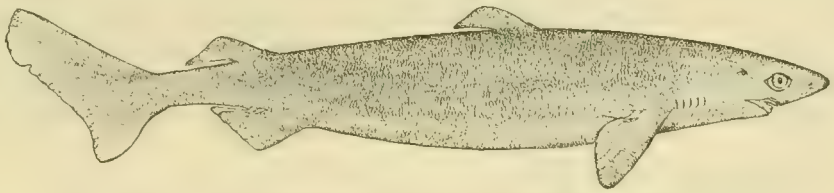

FIG. 18.—Portuguese shark (*Centroscymnus cœlolepis*). After Garman

Color.—Described as deep chestnut brown on the belly, as well as the back.

General range.—This rare deep-water shark, originally known from off Portugal, has since been taken at various other localities.[40] Its claim to mention here rests on the fact that it was once reported off Gloucester; on the specimen "taken off the coast of New England," just mentioned; and on Goode and Bean's (1896) statement that it is abundant on the slopes of our offshore banks at 200 fathoms and more.

Habits.—Little is known of its habits beyond the fact that it is a deep-water species regularly caught by Portuguese fishermen with hand lines, a fishery that Wright (Annals and Magazine of Natural History, series 4, Vol. II, 1868, p. 426) describes as follows:

> Some 600 fathoms of rope were let out, the first 30 or 40 fathoms of which had fastened to it at intervals of a fathom a series of small ropes, on each of which was a large hook baited with a codling. This fishing tackle remained below for about two hours, when they commenced to haul it in. When it arrived at the last few fathoms, they pulled in, one after another, five or six specimens from 3 to 4 feet long. The species was the *Centroscymnus cœlolepis* Bocage and Capello. These sharks, as they were hauled into the boat, fell down into it like so many dead pigs.

This species is viviparous, 13 to 16 young having been found in females caught off Portugal.

[40] Known from Portugal, the Mediterranean, Madeira, Japan, the Faroes, and recently reported from Iceland by Sæmundsson (Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i Kjøbenhavn [Copenhagen], Bind 74, 1922, p. 167).

17. **Black dogfish** (*Centroscyllium fabricii* Reinhardt)

Jordan and Evermann, 1896–1900, p. 56.
Garman, 1913, p. 231.

Description.—As pointed out elsewhere (p. 44), the notched margin of the upper tail lobe distinguishes this rare shark at a glance from the spiny dogfish, with which it agrees in the possession of a long pointed spine at the front edge of each dorsal fin, the second being longer than the first. It differs further in that its dorsal spines are deeply grooved on each side, whereas in the "dog" they are rounded; in the location of the ventral fins, the rear axils of which stand almost directly under the front origin of the second dorsal instead of some distance in front of it; in its small pectorals of rounded outline; in the structure of its teeth, each of which is tridentate, with sharp points; in its broad rounded snout; and in its very dark color. Like the spiny dogfish, it lacks an anal fin.

Size.—The specimens so far described have ranged from 2½ to 3½ feet in length—that is, about the same size as the spiny dogfish.

Color.—Uniform dark brown to black, below as well as above.

General range.—Positive records for this shark are from Greenland, Iceland,[41] rather deep water off the outer banks, Grand to Georges,[42] off the Hebrides and Faroes where two specimens were taken by the Norwegian fisheries steamer *Michael Sars* in 400 to 600 fathoms, and from the North Atlantic (two specimens in the British Museum). But since Tate-Regan [43] thinks a specimen that he examined

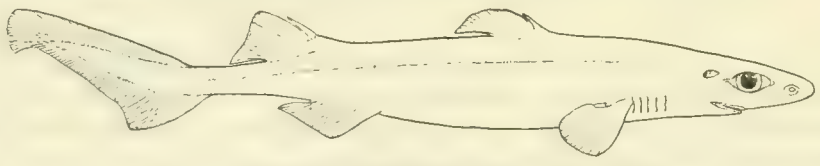

FIG. 19.—Black dogfish (*Centroscyllium fabricii*). After Garman

from the Falkland Islands is identical, while Goode and Bean (1896) tentatively refer to it a young shark from the Gulf of Mexico, and the Japanese *C. ritteri* seems hardly distinguishable, the black dogfish may prove to have a cosmopolitan range in deep waters.

Occurrence in the Gulf of Maine.—Evidently the black dogfish is very rare in the Gulf of Maine, for it has so far been reported there only from Georges Bank, from the slope off Browns in 200 fathoms, and vaguely from off Gloucester, which might mean any of the fishing grounds between Cape Cod and Newfoundland. However, it has been taken repeatedly on the offshore slopes of the Nova Scotian Banks in 200 to 250 fathoms, whence a number were brought into the Bureau of Fisheries by halibut fishermen many years ago.[44] Nothing is known of its habits.

[41] Sæmundsson. Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i Kjøbenhaven, Bind 74, 1922, pp. 159-205.
[42] According to Garman (1913), Greenland to New York.
[43] Annals and Magazine of Natural History, Vol. II, Eighth Series, 1908, p. 49. London.
[44] For list of these specimens see Bean (1881, p. 116).

THE NURSE SHARKS. FAMILY SCYMNORHINIDÆ

The nurse sharks, like the spiny dogfishes, lack anal fins, but there are no spines in their dorsal fins and the teeth in the upper jaw are noticeably unlike those in the lower.

18. **Greenland shark** (*Somniosus microcephalus* Bloch and Schneider)

NURSE SHARK; SLEEPER SHARK; GURRY SHARK; GROUND SHARK

Jordan and Evermann, 1896–1900, p. 57.
Garman, 1913, p. 241.

Description.—The Greenland shark is notable for its very small dorsal fins, without spines, the second being of about the same size as the first, and for small pectorals hardly larger than the ventrals, coupled with the absence of an anal fin and with a tail of more "fishlike" form than that of most other sharks except the mackerel-shark tribe. Bearing these points in mind, particularly the absence of anal fin and dorsal spines, it can not be confused with any shark common in our Gulf. The location of the first dorsal—about midway between pectorals and ventrals—is the most obvious "field mark" to distinguish it from the rare *Echinorhinus brucus* (p. 55). We may note further that the Greenland shark is compara-

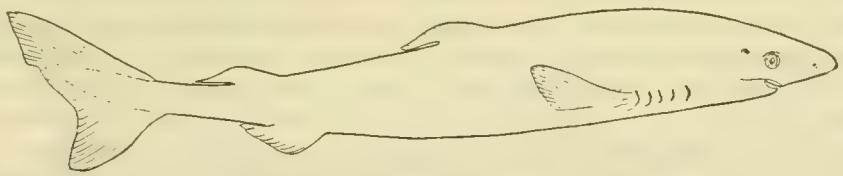

FIG. 20.—Greenland shark (*Somniosus microcephalus*). After Garman

tively stout shouldered, tapering thence toward the tail; that its snout is blunt and rounded as Scoresby [45] represented it a century ago (many more recent figures of it are caricatures in this respect); that the gill openings are short and located low down on the sides of the neck; and that the teeth are unlike in the two jaws, being narrow in the upper, and broad, square tipped, and notched at the outer corners in the lower jaw.

Size.—This is one of the larger sharks. It is said to grow to a maximum length of 24 feet, but few, if any, actually reach such a size, 18 feet being unusual. One 15 feet long has been taken in Cape Cod Bay; another of 13½ feet (now in the Museum of Comparative Zoology) in Massachusetts Bay. Perhaps 8 to 12 feet would be a fair average for adults; nor is this size exceeded often among the hundreds annually caught about Iceland and Greenland.

General range.—Arctic seas; south to Cape Cod in the western North Atlantic, and to France in the eastern North Atlantic; to Oregon in the Pacific. It is the object of a regular fishery in Greenland, Iceland, Norway, and Spitzbergen.

Occurrence in the Gulf of Maine.—Although there is no reason to suppose that the Greenland shark is ever common in our Gulf or appears there other than as a

[45] An account of the Arctic Regions, and of the whale fishery, 1820, Vol. II, Pl. XV, figs. 3 and 4.

straggler from the north, its presence has been signalized on several occasions. Two specimens, for example, were taken in the neighborhood of St. Andrews in 1915 (one caught in a weir and the other on a long line). It has also been reported off Eastport, 80 miles off Cape Elizabeth, near Cape Ann, off Marblehead and Nahant, in Massachusetts Bay, off Barnstable in Cape Cod Bay (where R. E. Smith killed the fish noted above many years ago), at Provincetown, and in Cape Cod Bay off the entrance to the Cape Cod Canal, where a large one between 10 and 11 feet long was taken by a trawler in April, 1924. Although the localities of capture are so widely scattered, the total number of specimens definitely recorded from the Gulf of Maine is not over a dozen. Of recent years this has certainly been so rare a shark within the limits of the Gulf of Maine that one might fish a lifetime without seeing it, but in old days, when right whales were still plentiful and many of them were killed off the Massachusetts coast, it may well have been more abundant—such, indeed, is the rumor—for in its northern home it is attracted from afar to feed on whale, seal, and narwhal carcasses, from which it gets one of its popular names. When there has been a big killing of narwhals, such as falls to the lot of the Eskimo of Disko Bay at rare intervals, schools of these great carrion eaters may linger in the vicinity for several years.

Food.—This is one of the most sluggish of sharks, offering no resistance whatever when hooked, entirely inoffensive[46] but extremely rapacious, biting on anything in the way of meat, the more putrid and ill-smelling the better. Apart from carrion, which can be available only at rare intervals, it feeds on fish and seals. Cod, ling, and halibut have been found in its stomach, and an entire reindeer has been found in one. The specimen from Cape Cod Bay, mentioned above, contained half a dozen flounders and a large piece bitten out of the side of a seal. It is also known to eat crabs. An old story has it that the Greenland shark attacks live whales, but this is not confirmed by recent observation and is most improbable. Although so sluggish, apparently it is able to catch live seals, for not only have whole ones been found in its stomach, but when sharks gather seals soon become very scarce.

Habits.—The nurse is a bottom swimmer, seldom coming to the surface except in pursuit of the scent of carrion, such as of a whale being cut up. In Icelandic waters it comes up into water as shoal as 40 to 50 fathoms in winter, but in summer descends to 200 or 300 fathoms, lying chiefly on the muddy or clay bottom of troughs or folds in the sea bottom. In the Gulf of Maine, then, it would be more apt to be found in the deep basin than near land.

Breeding habits.—Nothing definite is known of its breeding habits. Its close relative, *Somniosus brevipinna*, of the Mediterranean, the coasts of Portugal, and of Japan, has long been known to be viviparous, and the early belief was that this also applies to the Greenland shark, Faber stating that its young are born in July and August. However, no one has recently reported a fetus in a Greenland shark, and the fact that females often contain great numbers of eggs (up to the size of

[46] Tales to the effect that it attacks Greenlanders in their kyaks are apparently mythical, and Doctor Porsild, director of the biological station at Disko, said that the Eskimos do not fear it as they do the killer whale; nor is there any authentic instance on record of a shark attacking a human being about Iceland.

goose eggs) all at about one stage of development,[47] has led to the common belief in Iceland that it is oviparous. For ourselves, it seems so unlikely that, of two sharks closely allied in every way, one should retain the fetuses in the oviducts until they are of considerable size and fully developed, and the other lay eggs, that we incline to the belief that the Greenland shark will also prove to be viviparous.

Commercial importance.—Were the nurse more plentiful in our waters it might be a useful scavenger. Off Iceland it is caught for its liver oil, and in the Arctic the flesh is dried for dog food. It is very interesting to note in passing that while the meat is perfectly wholesome when dried, it produces a sort of intoxicant poisoning when eaten fresh.[48]

THE BRAMBLE SHARKS. FAMILY ECHINORHINIDÆ

The only living representative of this family (it is represented among the tertiary sharks) resembles the nurse-shark family (p. 53) in lacking both anal fin and dorsal spines, but its teeth are alike in the two jaws.

19. **Bramble shark** (*Echinorhinus brucus* Bonnaterre)

Jordan and Evermann (*E. spinosus*), 1896–1900, p. 58.
Garman, 1913, p. 243.

Description.—As pointed out above, the location of the first dorsal fin, above the ventrals instead of about midway between the latter and the pectorals, is

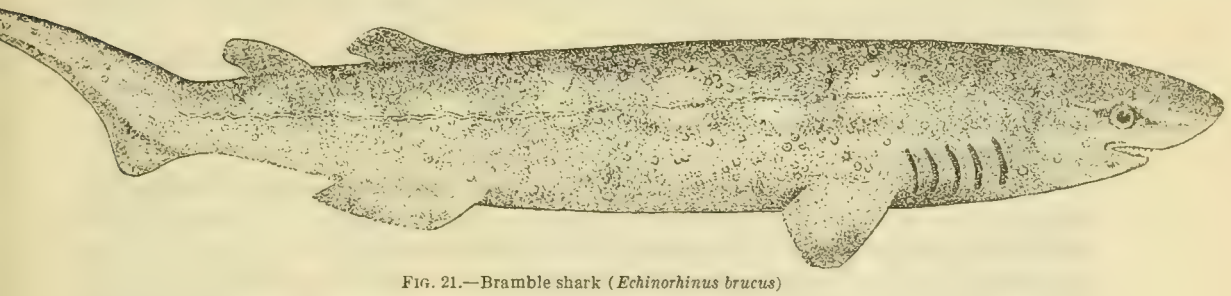

FIG. 21.—Bramble shark (*Echinorhinus brucus*)

the readiest field mark to enable separation of this form from the Greenland shark. *Brucus* also differs from the latter in its more slender form, longer gill slits, and especially in the fact that the teeth are alike instead of unlike in the two jaws.

Size.—The largest (a specimen from British waters) of which we have found a record was 9 feet long, and it has been credited with a weight of 400 pounds.

[47] Smitt (Scandinavian Fishes, 1892) describes one with "innumerable" small eggs and discusses this question, and Helbing (Nova Acta, Kaiserlichen Leop.-Carol. Deutschen Akademie der Naturforscher, vol 82, 1904) has recently given a good description and figures of fetuses of *Somniosus brevipinna* (as *Læmargus rostratus*), with a discussion of the relationship of this species to the Greenland shark (as *Læmargus borealis*).

[48] This is described by Jensen in "The Selachians of Greenland." Saertryk af Mindeskrift for Jepetus Steenstrup, pp. 12–14, 1914. Translation by A. H. Clark, Science, New Series, Vol. XLI, Jan.–June, 1915, p. 796.

Color.—Described as dark brown above, with or without darker blotches; lower surface lighter to white.

General range.—Formerly thought to be confined to the eastern Atlantic, off the coasts of Europe and north Africa, and to the Mediterranean in rather deep water, this shark has since been recorded from the Cape of Good Hope, the Pacific, and from Australia. Apparently, however, it is rare everywhere, unless it be that the rarity of capture is due to its habit of living at considerable depths.

Occurrence in the Gulf of Maine.—A single specimen of this little known shark came ashore at Provincetown in December, 1878, and this still remains the only record of it from the western Atlantic.

Habits.—Nothing is definitely known of its habits or whether it is a regular inhabitant of the continental slope at and below 200 fathoms, as its wide distribution and proclivity for deep water suggests.

SKATES AND RAYS

Skates, with their disklike outlines, thin as a shingle, and their long tails, are familiar objects along our shores. The Gulf of Maine supports four species in great abundance, while several others have been recorded on rare occasions. So far as the local fauna is concerned, this tribe falls into three groups—first, the skates (family Rajidæ) with comparatively short tails and without spines; second, the sting rays (families Dasybatidæ and Myliobatidæ) with long whiplike tails armed with stiff spines; and third, the torpedo (family Narcaciontidæ), interesting because provided with electric organs capable of giving a strong shock. All our common species belong to the first group.

Among skates and rays, as among sharks, fertilization is internal and the modification of the posterior edges of the ventral fins into rodlike semitubular claspers—the copulatory organs—distinguishes males from females at a glance. Some families are viviparous; others lay eggs.

The common skates look so much alike that fishermen seldom discriminate between them but speak of them all, large and small, simply as "skates." For this reason we know very little about the individual differences in habits between the several species. All, however, live chiefly on or close to the bottom, moving through the water by undulations of the flexible pectoral fins, steering themselves with the tail. All are decidedly omnivorous, feeding largely on the larger Crustacea—shrimps, crabs, lobsters—as well as on mollusks, worms, etc., and to a greater or less extent on fish. In the Gulf of Maine they are a nuisance, for they bite the hook readily and often are caught in great numbers in otter trawls. To give some idea of their abundance on the offshore banks I may note that the average number of skates (all species together) taken on Georges Bank, per trip of 4 to 7 days, on 25 trips by several trawlers, January to December, 1913, was approximately 800, the largest catch being 4,521 skates, the poorest 82. Whether they are equally abundant on Browns Bank is not clear, for though they are familiar enough there, no statistics as to the actual numbers caught are available. Skates are as plentiful inshore as on the banks, as appears from the following representative catches on long lines:

1. 13 miles from Gloucester, 2,540 baited hooks. Total fish caught, 540; skates, 65; dogfish, 321.

2. 15 miles off Monhegan, June 24–25, 1913. Total fish caught, 5,463; skates, 170.

3. 20 miles east of Cape Cod, November 11, 1913. Total fish caught, 6,532; skates, 202.

4. Jeffreys Ledge, December 11–12, 1913. Total fish caught, 3,996; skates, 62.

Now and then a long line comes in with a skate on almost every hook, but this is unusual. Fishermen report them as present on the inshore as well as the offshore fishing grounds throughout the year.

On our seaboard skates are salable only in special markets and are of so little commercial importance that in 1919, which may serve as a representative year, the total amount brought into the several ports of Maine, New Hampshire, and Massachusetts was only 102,739 pounds, valued at $550. From time to time a few have been utilized as fertilizer. All others caught are thrown overboard.

All our common Gulf of Maine skates are oviparous, laying large eggs with blackish or sea-green leathery shells, roughly oblong in outline with a hollow tendril at each corner by which they cling to seaweeds. The empty egg shells—"mermaids' purses"—are common on our beaches among the flotsam along high-water mark.

While still in the egg the embryos develop temporary external gill filaments from the walls of the gill clefts, but these disappear completely after hatching.

Many years ago Wyman (1867) published some notes on the development of one of our local skates (species not named) and figured the newly hatched young, since which time no attention has been paid to the development or life history of any of the species that occur in the Gulf of Maine. Probably, however, all spawn over a considerable part of the year with an incubation period of from 4 to 8 months, as is true of most of the European skates.[49] The sting rays are viviparous, but it is not likely that any of these strays from the south breed in the Gulf of Maine.

It is easy to tell a skate from a ray (at least among species with which we are concerned) by the presence or absence of a dorsal spine on the tail, while its large caudal fin places the torpedo at a glance, but identification of the several skates is proverbially difficult. In the following key we have endeavored to facilitate it by characters obvious in handling them at sea or on the dock.

KEY TO GULF OF MAINE SKATES AND RAYS

1. No long dorsal spine on the tail 2
   Tail with long dorsal spines (sting rays) 8
2. Two small dorsal fins, but no distinct caudal on the tail (includes all our common skates) .. 3
   There is a large triangular caudal fin as well as the two dorsals on the tail .. Torpedo, p. 68
3. The midline of the back, immediately over the backbone behind the shoulders, does not bear a row of large thorns, though it may be flanked by such 4
   The midline of the back bears a row of large thorns on the rear part of the disk, on the tail, or on both 5

[49] Clark (Journal of the Marine Biological Association of the United Kingdom, New Series, Vol. XII, No. 4, Oct., 1922, p. 629) described the eggs and young fry of several British species.

4. Teeth in about 50 rows; upper surface brown with dark spots ..... Little skate, p. 58
   Teeth in about 90 rows; upper surface usually with two large whitish eye spots near the rear angles of the disk [50] ..... Spotted skate, p. 60
5. The front angle of the disk is much blunter than a right angle; the whole upper surface of the disk is more or less thorny, with a row of very large thorns along the midline behind the shoulders ..... Prickly skate, p. 62
   Front angle of the disk is not blunter than a right angle; smoother species with noticeable thorns only in restricted patches 6
6. Front angle roughly a right angle with the snout hardly projecting; with stout thorns on the midline of the disk as well as of the tail 7
   Front angle more acute than a right angle, with the blunt tipped snout projecting; no thorns in the midline except on the tail ..... Barn-door skate, p. 66
7. Tip of snout blunt; outer corners of disk bluntly angular; thorns large ..... Brier skate, p. 64
   Tip of snout sharp-pointed; outer corners of disk rounded; thorns small ..... Smooth skate, *Raja senta*, p. 65
8. No dorsal fins on tail 9
   Tail with a dorsal fin in front of spine ..... Cow-nosed ray, p. 72
9. Tail rounded above, without a keel ..... Sting ray (*Dasybatus marinus*), p. 70
   Upper side of tail, behind the spine, with a distinct keel ..... Sting ray (*D. hastatus*), p. 70

THE SKATES. FAMILY RAJIDÆ

20. Little skate (*Raja erinacea* Mitchill)

COMMON SKATE; BONNET SKATE; SUMMER SKATE; HEDGEHOG SKATE; OLD MAID; TOBACCO BOX

Jordan and Evermann, 1896–1900, p. 68.
Garman, 1913, p. 337.

Description.—The most diagnostic characters are small size, absence of thorns along the midline of the back, and blunt nose. The anterior angle of the disk is blunter than a right angle and the tip of the snout is rounded, with margins bulging opposite the eyes. The teeth are in about 50 rows. Females have thorns scattered all over the upper surface except on the midline back of the shoulder girdle, especially prominent on head, snout, shoulders, and sides of tail. Males are less spiny, but in both sexes the spines on tail, shoulders, and along either side of the back ridge are especially strong. Males have bands of erectile hooks near the outer corners of the pectoral fins, presumably for holding the female. The outer angles of the pectorals are bluntly angular. The two dorsal fins are close together; the tail is about half the total length.

Size.—16 to 20 inches; at the most 2 feet in length. Northern specimens average larger than southern. A specimen 20 inches long is about 12 inches wide.

Color.—Grayish to dark brown, or clouded light and dark brown above, paler at the edges of pectoral fins; usually with many small round darker spots; white or grayish below.

General range.—Coastal waters off the Atlantic coast of America; Nova Scotia and Gulf of St. Lawrence to Virginia.

Occurrence in the Gulf of Maine.—This, the smallest of our skates, is the commonest and the most familiar from its habit of coming up into very shoal water in

[50] When this eye spot is lacking, as sometimes happens, it may be necessary to count the teeth to separate the "spotted" from the "little" skate.

summer and of stranding on the beaches, where dried skate carcasses are often to be seen. It occurs all along the coasts from the Gulf of St. Lawrence and Nova Scotia to Cape Cod, and much farther south. It is very abundant both on the New Brunswick and the Scotian sides of the Bay of Fundy, and is taken everywhere and anywhere along the coasts of Maine and Massachusetts, far more commonly, indeed, than one might suspect from the few definite records that have found their way into scientific literature. To what extent it enters into the skate population of the offshore banks is as yet unknown.

The little skate carries out a more or less definite migration up into shoal water in April and May, where it remains throughout the summer, autumn, and early winter, to return again to somewhat deeper water, say 30 to 50 fathoms, in Decem-

FIG. 22.—Little skate (*Raja erinacea*). After Garman

ber or January. In summer it is perhaps most numerous at depths of from 5 to 15 fathoms, many even following the shelving bottom up to within a few feet of low-water mark. Others, however, lie deeper. It has been trawled at 25 fathoms even in midsummer, for example. On Georges Bank it is probably to be found at 30 to 40 fathoms throughout the year, and there is no reason to suppose that it ever descends to any greater depth than this. It is common knowledge that skates are most abundant on sandy or pebbly bottom; however, they are likewise found on mud and over ledges. They bite the hook readily, affording amusement to vacationists.

Food.—Little skates are omnivorous. Hermit and other crabs, shrimps, worms, amphipods, ascidians ("sea squirts"), bivalve mollusks, squid, small fishes, and even such tiny objects as copepods have been found in their stomachs. Prob-

ably crabs loom largest in their diet, for more than 29 per cent of the skates opened by Field (1907, p. 26) contained them; 15 per cent had bottom-dwelling shrimps (Crago); 6 per cent had eaten squid. Launce, alewives, herring, cunners, silversides, tomcod, silver hake, all have been found in the stomachs of these skates.

Habits.—The spawning habits of the summer skate have not been followed in the Gulf of Maine, but off southern New England its eggs have been taken as early as March and in abundance during July, August, and September, both in fish traps and in dredges in a few fathoms of water. In all probability its breeding covers the same period north of Cape Cod—that is, eggs are laid in spring and early summer, hatching in late summer and autumn. The eggs measure about 2 by 2½

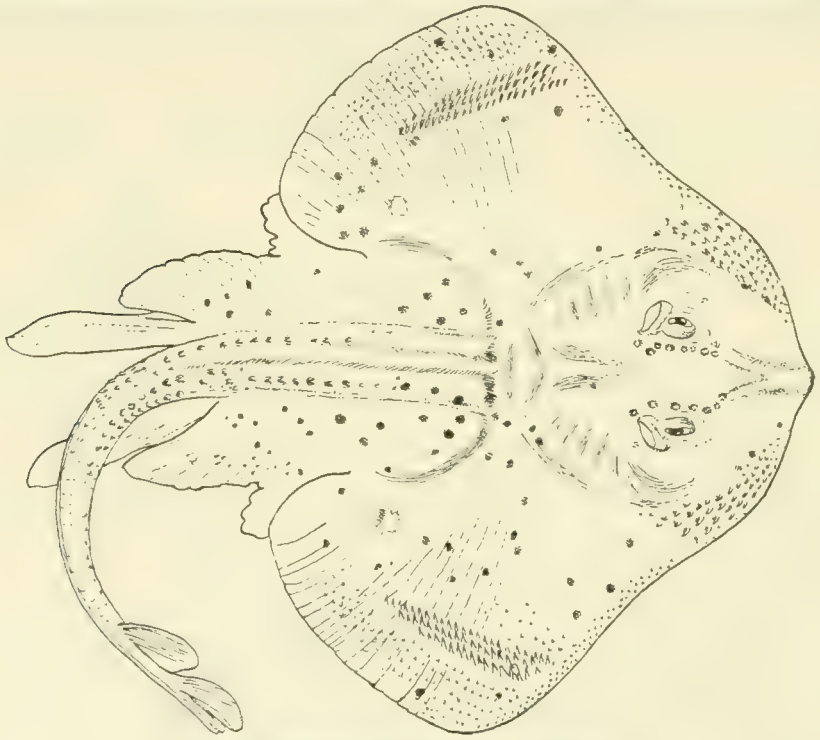

FIG. 23.—Big skate (*Raja diaphanes*). After Garman

inches, and the great majority of the empty skate eggs washed up on the beach belong to this species. Huntsman's observations suggest that young hatched near the head of the Bay of Fundy descend to deeper water the first winter, and this probably applies to the Gulf of Maine as a whole.

21. **Big skate** (*Raja diaphanes* Mitchill)

SPOTTED SKATE; WINTER SKATE; EYED SKATE

Jordan and Evermann (*Raja ocellata* Mitchill), 1896–1900, p. 68.
Garman, 1913, p. 339.

Description.—This skate is much like the little skate, but is larger, has more numerous teeth, and is of a different color. The front angle of the disk is much

blunter than a right angle, bulging opposite the eyes, and the tip of the snout is rounded. The teeth are in from 80 to 110 rows on a jaw instead of in only about 50 rows, as in *erinacea*, and they are sharper in males than in females. The backs of both sexes are rough, with sharp spines on the head, around the eyes, along the anterior margins of the pectorals, over the shoulders, and on the sides of the tail, but the midline of the back behind the shoulders is free of spines, at least in adults. Males have rows of retractile hooks on the outer parts of the pectorals. The two dorsal fins are close together; the outer corners of the pectorals are bluntly angular; the claspers in males reach about halfway back along the tail, which occupies about half the total length of the fish.

Size.—This skate grows to about 3 feet in length, commonly from 30 to 34 inches; specimens 32 inches in length are about 21 inches wide.

Color.—Light brown above with round darker brown spots. As a rule there is a large white eye spot with black center near the posterior angle of the pectoral fin, and often two smaller ones close to the latter. When these eye spots are present they serve to identify this skate at a glance; sometimes, however, they are lacking, in which case half-grown specimens so closely resemble the little skate that recourse must be had to the number of teeth to tell one from the other. There is a translucent or white area on each side of the snout in front of the eyes and the lower surface is white.

General range.—Atlantic coast of North America from New York northward to the Gulf of St. Lawrence, where it is common.

Occurrence in the Gulf of Maine.—This, the second in size of our skates, occurs commonly all around the Gulf of Maine from Nova Scotia to Cape Cod. There are many locality records from the Bay of Fundy as well as from the coasts of Maine and Massachusetts, and it probably makes up a large proportion of the skate population on Georges Bank. It is very plentiful in Massachusetts Bay, but so closely does a two-thirds grown big skate resemble the adult little skate (p. 58) that it is often impossible to tell to which species reports refer. It is said to come up into shoal water on sandy beaches, but we have no first-hand information to offer on this point, and at Woods Hole it is never found in water shoaler than 5 to 6 fathoms. South of Cape Cod the name "winter skate" is appropriate enough, for it is only during the cold season that it is common about Woods Hole. Similarly, it is said to be taken in larger numbers in winter than in summer in the Massachusetts Bay region, though we can not verify this. However, this is distinctly a misnomer in the northern part of the Gulf of Maine, for not only is it abundant in shoal water in the Bay of Fundy (e. g., Passamaquoddy Bay) from May to November, but to judge from temperature this probably applies to the whole coast line east of Cape Elizabeth.

Spotted skates feed on the same diet as do little skates. Rock crabs and squid are their chief diet, but they also take annelids, amphipods, shrimps, and razor clams, and they prey upon whatever small fish are available, the list at Woods Hole including smaller skates, eels, herring, alewives, bluebacks, menhaden, smelt, launce, chub mackerel, butterfish, cunners, sculpins, silver hake, tomcod, and hake.[51]

[51] From Vinal Edwards' and Linton's notes.

This skate is taken on hook and line, in weirs, and in otter trawls. The breeding habits of this species, as they apply to the Gulf of Maine, have not been traced. Its egg cases are little larger than those of the little skates—2½ by 1¾ inches.

22. **Prickly skate** (*Raja scabrata* Garman)

Jordan and Evermann (*Raja radiata* Donovan), 1896–1900, p. 69.
Garman, 1913, p. 340.

Description.—The prickly skate can be identified at a glance, or rather touch, by the fact that the midline of the back behind the shoulders, and of the tail, is armed with a row of very stout thorns. As in the little and spotted skates, the

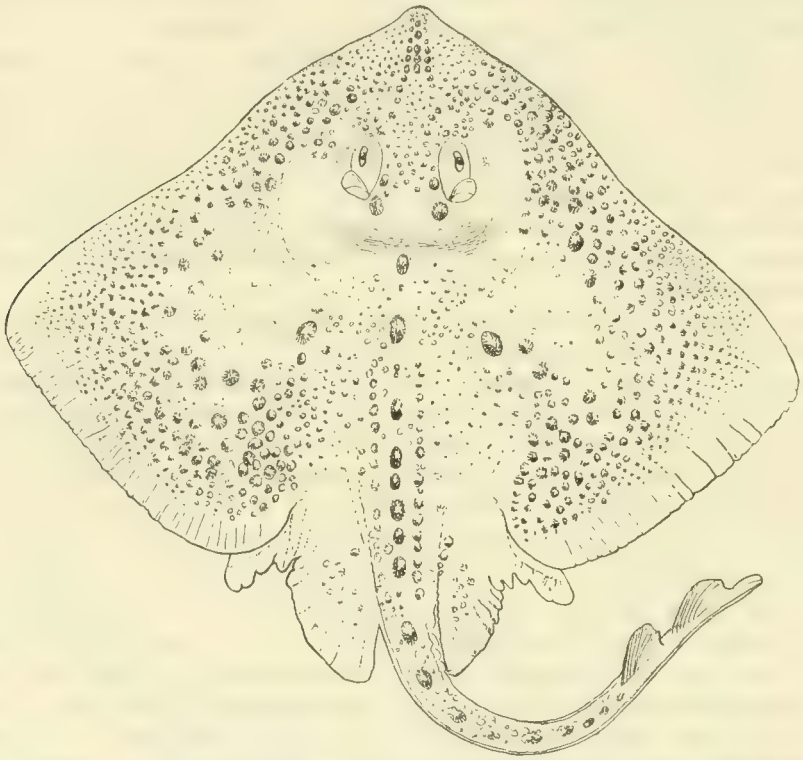

FIG. 21.—Prickly skate (*Raja scabrata*). After Garman

anterior angle of the disk is blunter than a right angle, its margin bulging somewhat abreast of the eyes, and the tip of the snout is blunt. There is a pair of large, hooked tubercles or bucklers on each shoulder, one in front of and one behind each eye, as well as one behind each spiracle, besides the mid-dorsal row of 14 or more just mentioned. Smaller thorns occur on the snout and are scattered generally over the upper surface of the pectoral fins. The bases of the spines on the pectorals are star-shaped, a very diagnostic character; those of the bucklers shieldlike. Males have two rows of hooked, erectile thorns near the outer corners of the pectorals, the latter being more angular than in either the little or spotted skates, while the two

dorsal fins are separated by a definite space in the adult but are confluent in the young.

Size.—This skate grows to 2½ feet in length, or slightly larger; males as small as 26 inches, nearly mature, have been found. Specimens 21 to 22 inches long are 15 to 16 inches wide.

Color.—Brown above, either uniform or slightly clouded with lighter and darker. Young ones are spotted with darker brown, but adults ordinarily lack these spots. Garman (1913, p. 34) mentions a partial albino, white above with a few reddish-brown and brown spots.

General range.—The prickly skate is a northern cold-water fish, its range hardly extending west or south of Cape Cod, for it appears but rarely and at long intervals at Woods Hole, nor is it known south of this. How far north it ranges is yet to be determined. It is plentiful along the east coast of Nova Scotia and in the Gulf of St. Lawrence where it lives indifferently on the ice-cold banks and in the warmer water in the bottom of the deep channels, but it has not been recorded from Labrador north of the Straits of Belle Isle nor so far as we can learn from the eastern shores of Newfoundland. In north European waters it is represented by an extremely closely allied if not identical form (*Raja radiata*), which occurs from the Bay of Biscay in the south to Greenland, Spitzbergen, and the White Sea in the north.

Occurrence in the Gulf of Maine.—The prickly skate is usually thought to be less common on our coast than either of the two species just mentioned, and it is certainly rare in very shallow water within our limits; but it is frequently taken on the New Brunswick side of the Bay of Fundy in depths of 10 fathoms or deeper, in 20 to 30 fathoms in St. Mary Bay (Nova Scotia),[52] while we ourselves trawled it (13 specimens) in 22 and 27 fathoms on sandy bottom in Ipswich Bay in July, 1913. Since it has also been recorded from Casco Bay, Ipswich Bay, Gloucester, Salem, Nahant, and Provincetown, it evidently occurs generally all along the shores of the Gulf in moderate depths. Judging from the considerable depths to which its European relative descends—it has been trawled down to 450 fathoms—skates caught in the deeper parts of the Gulf are more likely to belong to this than to either of the preceding species, and it may be the prevalent skate on the offshore banks. It has not been recorded below about 200 fathoms off our coasts.

Habits.—Nothing is recorded of its habits in the Gulf, nor, so far as we can learn, have its eggs or young ever been definitely recognized there, but probably what is known of the spawning habits of its European representative applies equally here, briefly, that it comes up from deeper water into shoal water in spring to spawn there during the summer, retreating once more to greater depths in winter; that the egg case measures about $2^1/_2$ by $1^3/_5$ inches (exclusive of its tendrils); and that the fry remain near land during their first winter.

Food.—The prickly skate, like most of its relatives, feeds indiscriminately on small fish, amphipods, worms, etc. Such, at least, is true of the European form. So far as we can learn no stomachs have been examined on this side of the Atlantic.

[52] According to Huntsman (1922a).

23. **Brier skate** (*Raja eglanteria* Bosc)

Jordan and Evermann, 1896–1900, p. 71.
Garman, 1913, p. 341.

Description.—The brier, like the prickly skate, is armed with a row of stout thorns along the midline of the back from shoulder to dorsal fin near the tip of tail. Otherwise, however, it is a much smoother species and its snout is more acute. There are groups of large spines opposite and behind the eyes and on the sides of the tail, with a pair on each shoulder. Elsewhere the upper surface of the disk

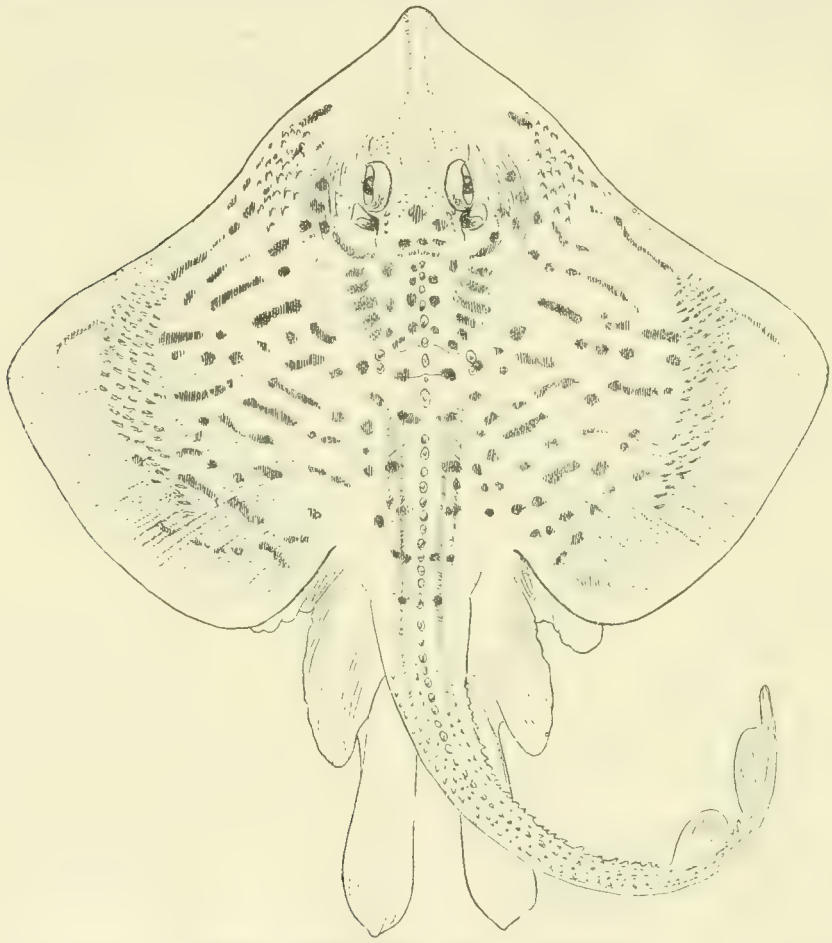

FIG. 25.—Brier skate (*Raja eglanteria*). After Garman

bears only very small but very sharp prickles, these being most numerous on the anterior parts of the pectorals, over the head and snout, and on the middle of the back and tail among the larger thorns, whence its common name. The males, we might add, are provided with several rows of large erectile hooks on the outer parts of the pectorals, which the females lack. The snout angle is roughly a right angle, its margin bulging less opposite the eyes than in any of the blunter-nosed

skates. The outer corners of the pectorals are distinctly angular. The dorsal fins are separated by a considerable interval in which there are usually one or two spines, instead of close together as in the little, spotted, and prickly skates.

Size.—The brier skate grows to a length of about 2 feet. Specimens of from 21 to 22 inches are 13 to 14 inches wide.

Color.—Described as brown above; the pectorals variously mottled, blotched, and barred with darker; a translucent or white space on each side of the snout; white below.

General range.—Off the eastern coast of the United States from Cape Cod to Florida.

Occurrence in the Gulf of Maine.—This is a southern species, uncommon even as far north as Woods Hole and decidedly rare in the Gulf of Maine, where it has been taken only at Provincetown and at Gloucester, the latter its most northerly outpost.

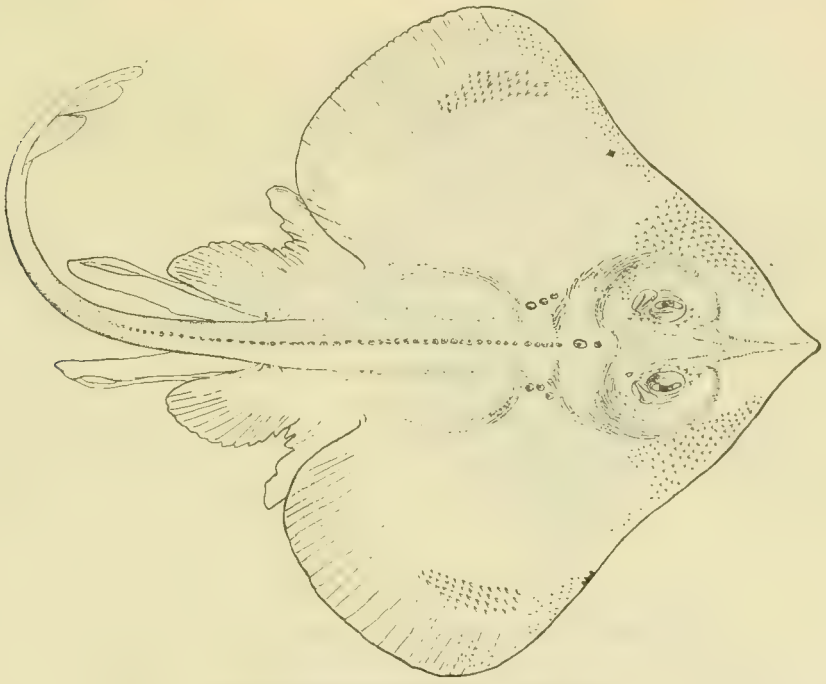

FIG. 26.—Smooth skate (*Raja senta*). After Garman

24. **Smooth skate** (*Raja senta* Garman)

Jordan and Evermann, 1896–1900, p. 71.
Garman, 1913, p. 338.

Description.—This skate is recognizable by its sharp snout, the rounded outline of the outer margins of the pectoral fins, and by the fact that the mid-dorsal line of thorns runs back only to about the middle of the tail, where it dwindles and disappears. There are also large spines on the front parts of the pectoral fins, on the ridges about the eyes, and a group on each shoulder; otherwise the back and top

of tail are rough with small spines only, except that males have the usual rows of hooks on the outer parts of the pectorals. The anterior snout angle is roughly a right angle; the tip of the snout itself is sharp instead of rounded. The two dorsals are close together, not separated by spines as in the brier skate.

Size.—The largest recorded specimen was 22½ inches long, the tail being almost exactly half the total length. Its width was 14 inches.

Color.—Rusty brown above clouded with darker, not spotted; no doubt white below like other skates. Young examples have been seen with white spots.

General range and occurrence in the Gulf of Maine.—Of the distribution of this skate, evidently very rare in our Gulf, nothing is known further than that specimens have been taken on LaHave Bank and off Provincetown, on the strength of which it has usually been described as "a deep-water form, Banks of Newfoundland Cape Cod." Nothing whatever is known of its habits.

FIG. 27.—Barn-door skate (*Raja stabuliforis*)

25. **Barn-door skate** (*Raja stabuliforis* Garman)

Jordan and Evermann, 1896–1900 (*Raja lævis* Mitchill), p. 71.
Garman, 1913, p. 341.

Description.—The barn-door skate is easily identified by its large size, very pointed snout, and smooth skin. The mid-dorsal thorns are comparatively small and run only from the hinder part of the back over the tail; otherwise the spines, which are very small, are restricted to the sides of the tail, top of the tip of the snout, and to narrow bands along the front edges of the pectoral fins, in front of and between the eyes, with a few scattered here and there over shoulders and back. Thus the whole upper surface is smoother than in any of the other skates. The male is provided with the erectile hooks on the outer parts of the pectorals common

to all skates of this genus. The anterior angle of the disk is sharper than in other skates, being more acute than a right angle. The snout itself is long but blunt tipped, the outer corners of the pectorals are angular, and the disk as a whole is diamond or lozenge shaped. The two dorsal fins are separated by a short space, with one or more spines, and the tip of the tail extends farther beyond the second dorsal than in most skates.

Size.—The barn-door is our largest skate, growing to a length of 6 feet or even more. One of 58 inches length was 42 inches wide with a tail 27 inches long.[53]

Color.—The barn-door, like so many sea fish, varies in color. As a rule the upper surface is brown, usually of a distinctly reddish hue, variously marked with small scattered darker spots or blotches of varying size, often with pale marblings or waterings. The lower surface is not as uniformly pale as in most skates, its gray or white ground being shaded with darker toward the snout and speckled with black over the abdomen.

General range.—Atlantic coast of North America from the Gulf of St. Lawrence and the outer coast of Nova Scotia, where it is common, to Florida. In European seas it is replaced by a very close ally, the "common skate," *Raja batis.*

Occurrence in the Gulf of Maine.—This is a common fish off the New England coast and in all parts of the Gulf. Any very large skate taken or reported there is almost certain to be a "barn-door." Following the coast around from east to west we find it reported as plentiful off the Nova Scotian shore; it is known from St. Mary Bay; is found very generally though not abundantly in the Bay of Fundy and up in Passamaquoddy Bay; is reported from Eastport, Casco Bay, and generally along the coast of Maine; is known from various localities in Massachusetts Bay, where we have seen many caught; and is taken in abundance by the trawlers on Georges Bank.[54] In short, it is to be expected anywhere in the Gulf. Like most other skates, it is often taken in shoal water in summer; seldom or never in winter. Huntsman tells us that it comes up into Passamaquoddy Bay from May to November. We took one nearly 5 feet long at Cohasset in Massachusetts Bay in only a couple of fathoms of water in midsummer. Indeed, it is often stranded on the beaches. This inshore migration, however, does not involve the entire stock—witness its presence in 20 to 60 fathoms on Georges Bank and off Cape Cod throughout the year and the fact that it is reported by fishermen and has been trawled by vessels of the bureau below 100 fathoms in summer. In the warmer waters off the south coast of New England it comes inshore in spring and autumn, descending to deeper water in summer.

Habits and food.—Barn-door skates, like other skates, are bottom swimmers, preferring smooth to rocky ground, but the fact that the lower surface is more or less pigmented instead of white suggests that it hugs the bottom less closely than do other skates. Garman, the foremost authority on this group, has pointed out that the spines on the snout of this skate are usually worn smooth, as though used to dig in the mud or sand—very likely it thus obtains the bivalves that form part of its diet. It also feeds on worms, various crustaceans, particularly large rock crabs

[53] Described by Garman (1913, p. 342).

and lobsters, on squid, and on fish. Probably, thanks to its large size, it is more destructive to the latter than are any other skates. At Woods Hole the list includes spiny dogfish, alewives, herring, butterfish, launce, cunners, tautog, menhaden, sculpins, silver hake, hake, and flatfish. No doubt cod, haddock, etc., suffer to some extent from this skate on the offshore fishing grounds, for its European relative is a well-known enemy of the cod, and there is no reason to suppose that our "barn-door" is less voracious. It is a strong, active swimmer, as anyone who has landed a large one on a hand line will agree. It bites readily on almost any bait, and is often caught on hand and long lines as well as in the otter trawl and in weirs along shore.

Breeding habits.—Very little is known of its breeding habits. Probably it spawns when in shoal water, that is, during the warm season of the year. Eggs, probably belonging to the barn-door, are 5¼ by 2¾ inches.[55]

Commercial value.—The barn-door skate is of no commercial value except as entering into the small landings of skates mentioned on page 57.

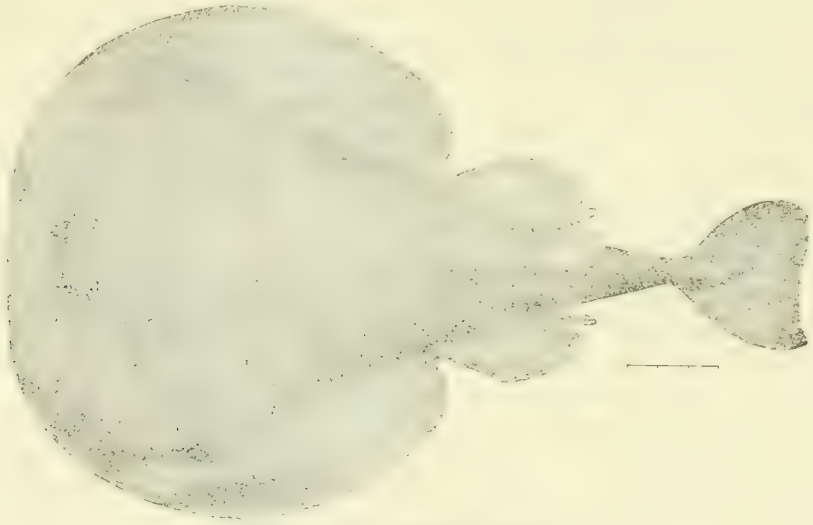

FIG. 28.—Torpedo (*Narcacion nobilianus*)

THE TORPEDOES. FAMILY NARCACIONTIDÆ

26. Torpedo (*Narcacion nobilianus* Bonaparte)

ELECTRIC SKATE; CRAMPFISH; NUMBFISH

Jordan and Evermann (*Tetranarce occidentalis* Storer), 1896–1900, p. 77.
Garman, 1913, p. 310.

Description.—No one would be apt to mistake the torpedo for any other skate or ray, the rounded outline of the disk and the large caudal fin identifying it at a glance. Furthermore, the skin is soft and naked, without the spines so characteristic of all our common skates. The disk is roughly subcircular, truncate in front, and considerably broader than long. The eyes are very small and are set far for-

[55] Doctor Garman supplied this note.

ward. The two dorsal fins, of which the anterior is the taller, stand at the forward end of the tail, the anterior, indeed, partly above the bases of the ventral fins, and they are separated by an interspace nearly as long as the second dorsal fin. The tail fin is of ordinary fish form -triangular and about three-quarters as long as deep. The tail is shorter than in the skates—that is, it occupies only about one-third the total length of the fish. The most interesting feature of the torpedo is its electric organ and its ability to give electric shocks of considerable strength to anyone touching it.

Color.—Dark chocolate brown above; lower surface white except that the edges of disk, fins, and tail are of the same dark chocolate tint.

Size.—Adult torpedoes are usually 2 to 5 feet long and heavy for their size. Specimens taken at Woods Hole average about 30 pounds, ranging from 4 or 5 up to 75 pounds. Torpedoes as heavy as 200 pounds have been recorded, and they have been taken up to 170 pounds or more in Massachusetts Bay.

General range.—Tropical and temperate parts of both sides of the Atlantic: Maine to Cuba on the American coast.

Occurrence in the Gulf of Maine.—The torpedo is a southern fish, which, like so many others, finds the northerly limit to its common occurrence at Cape Cod. It strays past the cape into the Gulf of Maine often enough, however, to be looked upon as a regular, if rare, summer visitor. It has been recorded even as far east as Eastport (not, however, in the Bay of Fundy), as well as at various other localities along the coast of Maine (e. g., Williamsport, off Seguin Island, and Casco Bay); likewise at Cape Ann, in Cape Cod Bay, near Provincetown, and along the outer shores of Cape Cod, so it would be no surprise to find it anywhere along our shores. It has also been reported from Georges Bank. Most of the records date back many years. It is said to have been unusually common in the year 1819 and for four or five years thereafter. Again in 1845 about a dozen came ashore or were otherwise taken near Provincetown. It is as apt to be found in our Gulf now as then, for one was seined off Seguin in about 1880, another was caught on a long line set from the *Grampus* on LaHave Bank in the summer of 1890, one was taken in a trap at Wood Island near Cape Elizabeth in 1894, and torpedoes were collected by Dr. W. C. Kendall of the Bureau of Fisheries at several localities along the coast of Maine in 1896. West of Cape Cod it is much more numerous, appearing not uncommonly from May to November about Woods Hole.

Breeding and habits.—The torpedo, like others of its tribe, is a bottom fish. It feeds chiefly on small fish and to some extent on Crustacea. Probably it does not succeed in breeding in the cold waters of the Gulf, but at Woods Hole it has been found to contain nearly ripe eggs by the end of June. It is viviparous, the embryos having been figured by Garman (1913, pl. 61).

Commercial value.—Nowadays the torpedo is of no commercial value, but years ago before the use of kerosene oil was general its liver oil was considered equal to the best sperm for illuminating purposes.

THE STING RAYS. FAMILIES DASYBATIDÆ AND MYLIOBATIDÆ

27. Sting ray (*Dasybatus marinus* Klein)

STINGAREE; CLAM CRACKER

Jordan and Evermann (*Dasyatis centrura* Mitchill), 1896–1900, p. 83.
Garman, 1913, p. 382.

Description.—The most characteristic features of the sting ray are the very long whiplike tail without dorsal fins and the strong saw-toothed spines that the tail bears on its dorsal surface. The disk is roughly quadrangular, one-fourth wider than long, with the anterior corner much blunter than a right angle, the anterior and posterior margins nearly straight, and the lateral corners bluntly angular. The ventral fins are relatively much shorter than in the common skates. The tail is more than twice as long as the disk, rounded above and tapering regularly to a very narrow tip. The spines, of which there are from one to several,[56] are situated about one-fifth of the way back along the tail. Young sting rays are smooth-skinned, but adults bear scattered tubercles on the middle and hind parts of the back and on the back and sides of the tail, which become more and more numerous as the ray grows.

Size.—Maximum length, including the tail, about 12 feet.

Color.—The general ground tint varies according to the background.

General range.—Both sides of the tropical and temperate Atlantic, north on the American coast to Cape Cod, and (according to Smith [57]) not known south of Cape Hatteras.

Occurrence in the Gulf of Maine.—The only claim of the sting ray to mention here is that it has been recorded from Chatham, on the outer shore of Cape Cod, and that it is said to have been seen on the shoaler parts of Georges Bank. It has no real status as a Gulf of Maine fish, where it appears only as a waif from the south, though common enough as far east as Woods Hole, where it appears in June or early July. Beware of handling any skate with a long whiplike tail lest it prove a sting ray, for its spine is a dangerous weapon.

Breeding habits.—The sting rays are viviparous.

28. Sting ray (*Dasybatus hastatus* DeKay)

Jordan and Evermann (*Dasyatis hastata* DeKay), 1896–1900, p. 83.
Garman, 1913, p. 391.

Description.—This ray so closely resembles *D. marinus* that we need only point out that the tail bears a low keel on its dorsal surface behind the spines instead of being rounded above as in its relative.

General range.—Atlantic coast of America, Cape Cod to Brazil.

Occurrence in the Gulf of Maine.—This southern sting ray is mentioned here because recorded many years ago from Chatham on Cape Cod.

[56] There are three in a specimen figured by Garman and two in one we have examined.

[57] The fishes of North Carolina, by Hugh M. Smith. North Carolina Geological and Economic Survey, Vol. II, 1907, p. 44.

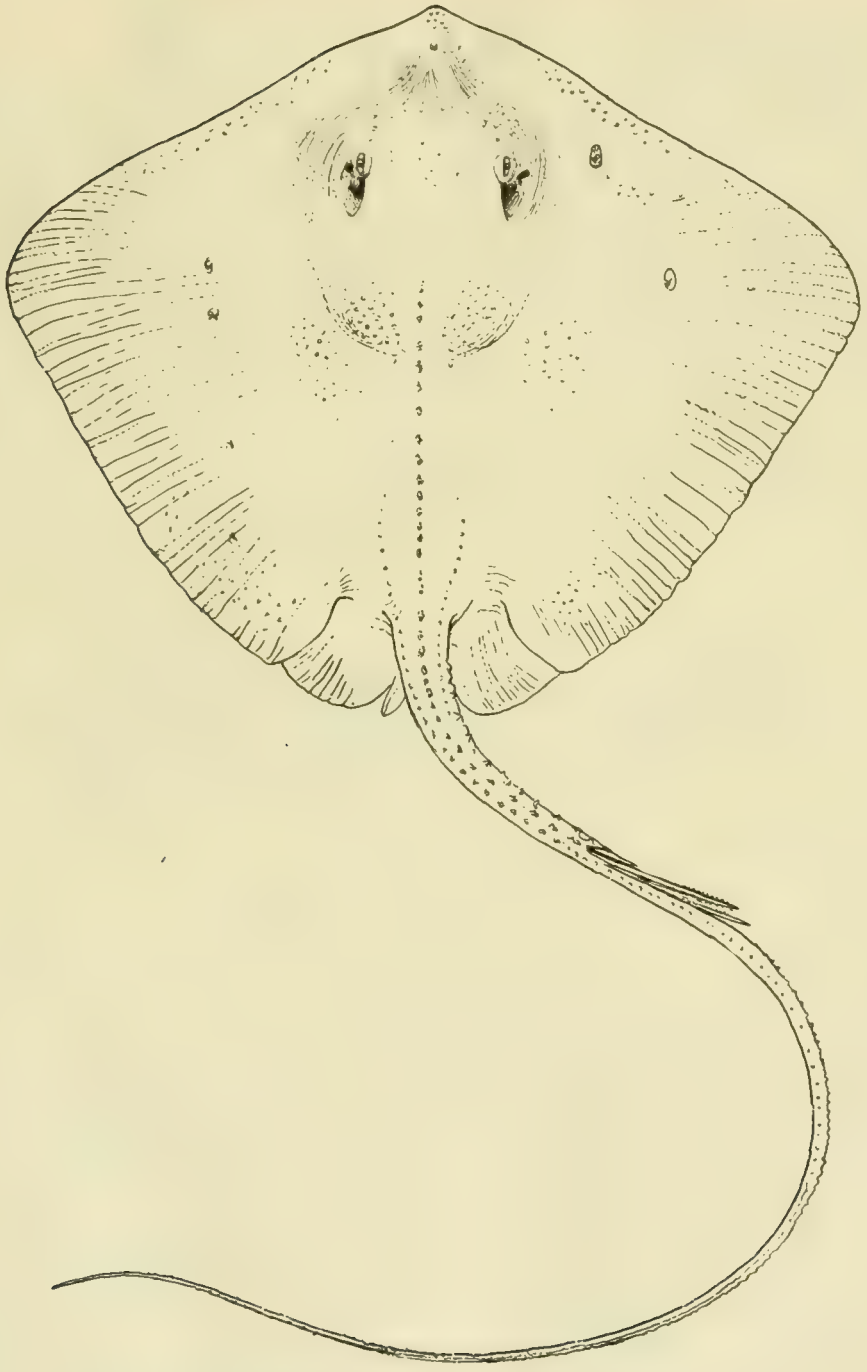

FIG. 29.—Sting ray (*Dasybatus marinus*). After Garman

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29. Cow-nosed ray (*Rhinoptera quadriloba* LeSueur)

Jordan and Evermann (*Rhinoptera bonasus* Mitchill), 1896–1900, p. 90.
Garman, 1913, p. 444.

Description.—The cow-nosed ray and all its close relatives are of such characteristic batlike outline, with head so peculiar and teeth so different from those of our other Gulf of Maine skates and rays, that once seen they are never apt to be mistaken for anything else. The anterior angle of the disk is much blunter than a right angle; the outer corners of the pectorals are acute, pointed, and their posterior margins distinctly concave. The ventral fins are comparatively very small, longer than wide, reaching but a short distance back of the posterior corner of the pectorals. There is a single small dorsal fin originating a short distance back of the bases of the ventrals, and immediately back of it stands a stout spine. The tail is hardly twice as long as the disk, whiplike and tapering to a very slender tip. The cranium

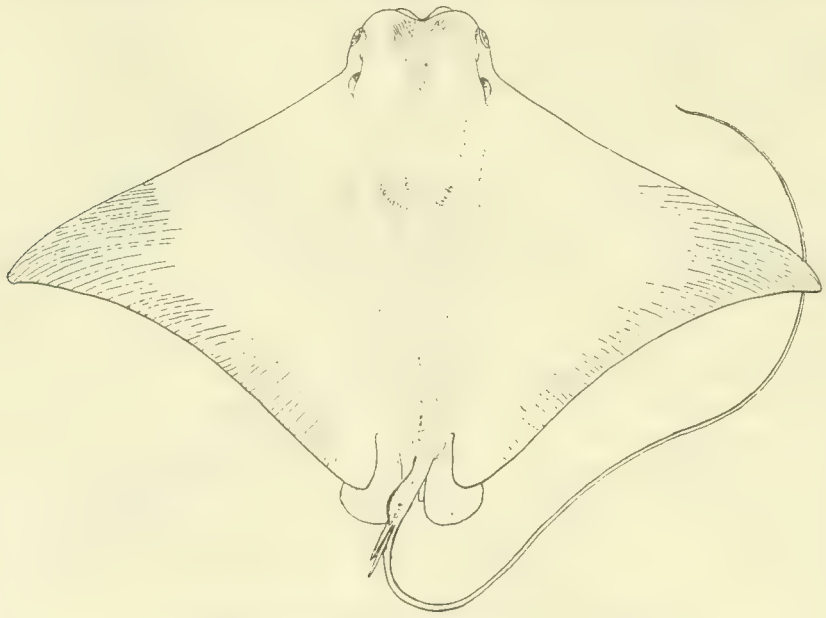

FIG. 30.—Cow-nosed ray (*Rhinoptera quadriloba*). After Garman

of the cow-nosed ray is raised above the general level of the disk with the large eyes set lateral instead of dorsal, and in front of the fins instead of far back as in other skates and rays. Its teeth are flat and arranged like the bricks or tiles in a pavement in a manner more easily figured than described.

Size.—The cow-nosed ray grows to a length of about 7 feet. In one about 33½ inches in total length the disk was 25 inches long by 32½ inches broad.[58]

Color.—Brown above; white below, except toward the outer corners of the pectoral fins where it is brownish.

General range.—Atlantic coast of the United States, Nantucket to Florida.

[58] Described by Radcliffe (Bulletin, U. S. Bureau of Fisheries, Vol. XXXIV, 1914 (1916), p. 279).

Occurrence in the Gulf of Maine.—The cow-nosed ray has even less claim to be called a Gulf of Maine fish than have the sting rays just mentioned, for while it is often taken in the traps at Woods Hole—145 in one day on one occasion—and is recorded from Nantucket, it has never actually been seen east or north of Cape Cod.

Chimæroids. Subclass Holocephali

THE CHIMÆRAS. FAMILY CHIMÆRIDÆ

The chimæras find their nearest affinities in the sharks but are separated from the latter by many important anatomic characters, the most obvious of which are the facts that there is no spiracle, there is but one gill opening on either side, the tail is symmetrical, and the gills are fringelike and free at the tips like those of bony fishes. In general aspect the chimæras remotely suggest the grenadiers (p. 467), but are easily separable from them by the location of the ventral fins, which are set far back under or behind the tips of the pectorals; by the fact that the fin on the back is separated by a deep notch into dorsal and caudal portions; by the very small eye; and by the large size of the pectoral fins, to list only the most obvious differences. There is no danger of confusing them with any other Gulf of Maine fishes, so curious is their appearance.

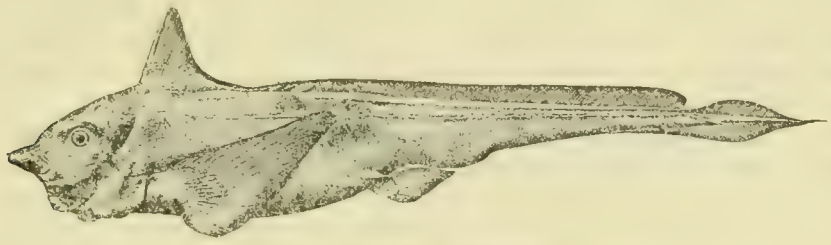

FIG. 31.—Chimæra (*Chimæra affinis*)

30. Chimæra. (*Chimæra affinis* Capello)

Jordan and Evermann, 1896–1900, p. 95.

Description.—The chimæra is deepest (one-seventh to one-eighth as deep as long) just behind the gills, tapering gradually backward to a weak slender tail, and is very soft bodied. The head is short, its dorsal profile oblique and prolonged into a short, soft, conical knob above the mouth. The forehead of the male bears a curious cartilaginous hook, armed with recurved prickles on its lower surface, which probably serve to clasp the female. The mouth is inferior in position, relatively small, the upper jaw with four, the lower with two, flat plates, set edgewise, in place of teeth, and with thick fleshy lips. The gill openings are vertical, set low down on the sides of the neck, and each is covered with a flap of skin paralleling the gill covers of bony fishes.

There are two distinct dorsal fins. The first of these originates over the gill opening, is triangular, about as high as long, and supported at its anterior margin by a stout spine that is free at the tip. The second dorsal is separated from the first by a space that probably varies in length, and is less than half as high as the

first, with straight margin. The small caudal fin is demarked from the second dorsal by a deep notch; it is lanceolate in outline, terminates rearward as a short whiplike filament, and extends a short distance forward on the ventral surface of the trunk, there being no separate anal fin. The ventrals and pectorals are both triangular and pointed, the latter being much the larger and reaching back nearly to the point of origin of the ventrals. In the male the lower part of each ventral fin is modified as a trifid clasping organ. The skin is smooth, or perhaps slightly prickly, the lateral line well developed, ramifying in several branches over the head.

This species[59] is a close ally of the well-known chimæra of north European seas (*C. monstrosa*), but is distinguishable from it by the facts that it has no separate anal fin, that there is a considerable free space between its two dorsal fins, that the outline of the second dorsal fin is straight, that its caudal filament is much shorter, and that its pectorals hardly reach back to the ventrals.

Color.—Leaden all over.

Size.—Maximum length about 3 feet.

General range.—Not uncommon on the continental slope of North America from the latitude of Cape Cod northward, in 300 to more than 900 fathoms.

Occurrence in the Gulf of Maine.—We mention the chimæra here because one (or more) was brought in from Georges Bank some time between 1877 and 1880.[60] It would be no surprise to find them on the seaward slope of the bank, for halibut fishermen have often caught them off LaHave and the more easterly banks. One has even been found in the harbor of Noank (Conn.), but there is no record of it in the inner parts of the Gulf of Maine.

Habits and food.—Nothing whatever is known of the habits of this chimæra; little more of the northern European species except that it is a ground fish, omnivorous, eating small fish, mollusks, Crustacea, echinoderms, and worms, and that it produces large eggs with horny oval cases, bearing threadlike filaments.

The bony fishes. Subclass Teleostomi

THE STURGEONS. FAMILY ACIPENSERIDÆ

The sturgeons—the only Gulf of Maine representatives of the ganoid fishes—share with the sharks an uneven tail with the vertebral column extending out into the upper lobe, but there is no danger of taking one for a shark as there is but one gill opening on each side, and the gills are inclosed by bony gill covers.

31. Sturgeon (*Acipenser sturio* Linnæus)

Jordan and Evermann, 1896–1900, p. 105.

Description.—Sturgeons are easily distinguished from all our other salt-water fishes by the fact that the head is covered by bony plates united by sutures, and the skin is armored by a row of large bony shields or bucklers along the mid-back,

[59] This fish is generally considered identical with a chimæra taken off the coast of Portugal, hence the choice of the specific name *affinis* instead of *plumbea*, by which the chimæra of North American waters was first known.

[60] Report, U. S. Commission of Fisheries, 1879 (1872), p. 788.

with two rows on each side, while the tail is of the "shark type," that is, with the axis bent upward and upper lobe much longer than the lower, and the nose is long and curiously depressed.

Each buckler bears a longitudinal keel and spine, those of the dorsal series being much larger than the others. On the average there are about 11 (10 to 16) bucklers in the dorsal row, 28 (26 to 34) in each upper lateral row, and 9 to 14 in each lower lateral row. The dorsal row extends from over the gill cover to the dorsal fin; the upper lateral from the corner of the gill opening back to the base of the tail fin; the lower lateral row from immediately behind the pectoral fin to the ventral fin, and again from the latter to the anal fin. The single rather small triangular dorsal fin is far back, its hind edge over that of the still smaller anal. The ventrals are likewise far back. The pectorals are set almost as low as the plane of the belly.

The body is elongate, comparatively slender and more or less pentagonal in cross section owing to the rows of bucklers, instead of rounded as in most bony fishes. In large fish the snout is about one-third the total length of the head (longer, comparatively, in small ones), depressed below the level of the forehead, and nearly flat beneath. The mouth, which is situated on the under side of the snout, is small and toothless (except in larval stages), with protractile lobed lips, and there are four pointed barbels in a row across the lower surface of the snout in front of the mouth.

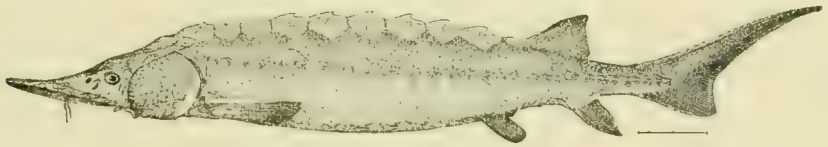

FIG. 32.—Sturgeon (*Acipenser sturio*)

Color.—Olive greenish or bluish gray above (in some seas reddish above), gradually fading on the sides and changing rather abruptly below the upper lateral row of shields to the white of the belly.

Size.—The sturgeon is a very large fish, specimens as long as 18 feet having been recorded from Europe and from New England; nor are 10-foot cows uncommon to-day in the Delaware River, where sturgeons are more plentiful than they are anywhere in New England. As a rule adults taken there run from 6 to 10 feet in length, with about 7 feet as the maximum for the males. Females weigh up to 350 pounds or more, while males average about 65 pounds in weight. Sturgeons (male and females together) averaged about 120 pounds in the Kennebec during the years when the fishery was carried on there. The fact that a fish between 11 and 12 feet long, taken near Helgoland in the North Sea, weighed 623 pounds will give an idea of the weight they sometimes attain.

General range.—Both sides of the North Atlantic, from Scandinavia to the Mediterranean on the European coast and from the St. Lawrence River to the Gulf of Mexico on the American coast.[61]

[61] Also recorded by Prince from Hudson Bay (Report of the sixty-seventh meeting of the British Association for the Advancement of Science, held at Toronto in August, 1897, p. 687).

Occurrence in the Gulf of Maine.—The sturgeon, like the salmon, shad, and alewife, is anadromous, spending most of its life and making most of its growth in the sea or in bays and estuaries, but running up the larger rivers to spawn. During its sojourn in salt water it may be expected anywhere off the coasts of the Gulf of Maine. There is definite record of it at sundry localities on both sides of the Bay of Fundy; in Penobscot Bay; Casco Bay; at the mouth of the Piscataqua River; on the Boar's Head—Isles of Shoals fishing ground, where several of from 3 to 4 feet were taken in the gill nets during April and May, 1913; both outside and in Boston harbor; off Provincetown; and off Truro on Cape Cod. It is well known in the St. John, Penobscot, Kennebec, and Merrimac Rivers, and has even been taken some distance up as small a stream as the Charles River. In fact, sturgeon once entered practically every stream of any size emptying into the Gulf of Maine. Writing of Massachusetts in 1634, Wood (1634, p. 37) described the sturgeon as "all over the countrey, but best catching of them be upon the shoales of Cape Codde and in the river of Merrimacke, where much is taken, pickled, and brought for England, some of these be 12, 14, and 18 foote long."

It is only the comparative rarity of the sturgeon in the Gulf of Maine that limits its commercial importance in the tributary rivers. In the year 1919 a total of 20,227 pounds was landed in Maine and Massachusetts. Supposing each carcass to have weighed 50 pounds (a very low estimate), this means a total of 400 fish at the most.

In former years, when our rivers were less obstructed and the sturgeons more plentiful, a fishery was intermittently maintained in the Kennebec, but as far back as the year 1880 the catch for the year was only 250 fish yielding 12,500 pounds of meat. So far as we can learn the open Gulf has never supported a sturgeon fishery, the few taken there being picked up accidentally in drift nets, traps, or weirs.[62]

Habits.—Although much attention has been paid to the sturgeon in other parts of the world because of its great economic importance, knowledge of its movements in the Gulf of Maine is of the scantiest. The large adult fish enter the mouths of our rivers sometime late in the spring in company with the salmon, shad, and alewives, slowly working their way upstream beyond tidewater before they deposit their eggs. Spawning takes place, so far as known, in May, June, and perhaps as late as July. Such, at least, is its season in north European waters, and what little is on record of its movements in northern New England is of the same tenor. It has been suggested that some may spawn in brackish water, with which the fact that females with large eggs have been taken about Woods Hole in June and July (that is, at the height of the spawning season), is in accord.

A single female fish may produce as many as 2,400,000 eggs, which hatch in about a week [63] after fertilization. Judging from European experiences with artificially reared sturgeon of this species, the larvæ may be expected to reach a length of 12 mm. within five days after hatching; 16 to 17 mm. at two weeks; 20 mm. at four weeks; and 4 to 5½ inches at two months.

[62] The short-nosed sturgeon (*Acipenser brevirostrum* LeSueur) was reported from Boston harbor and from Rockport, Mass., many years ago, but it is probable that the specimens in question were small common sturgeons.

[63] Ryder (Bulletin, United States Fish Commission, Vol. VIII, 1888 (1890), p. 231) has given an account of the spawning habits and early development of the sturgeon.

The old fish return to the sea after spawning, but as yet we have no idea how many years in succession a given fish may spawn or to what age sturgeons live. Apparently some of the young fish take to the sea at one year while others live for two or three years in the rivers in which they are hatched; for while sperlets of from 5 to 6 inches in length are found at the mouth of the Delaware River, as well as in the Elbe on the other side of the Atlantic,[64] and in the North Sea, young sturgeon as long as 18 to 20 inches are taken in winter both in the Delaware and in the Merrimac Rivers. Three marked fish in the Elbe were found to have grown as follows: The first from 17 to 38 cm. from June 17 until the following April; the second from 43½ to 64 cm. from April 9 until the following December; and the third not at all from November until the following February, suggesting that the sturgeon, like many other fishes, makes most of its growth during the warm months. By the time they have reached a length of 3 feet or so all sturgeons are either in the sea or about the river mouths, and few of them become sexually mature until they grow to about 4 feet or more in length. How long a period is covered by this growth is not known, but immature fish of from 3 to 4 feet in length are common about Woods Hole throughout the summer season, at the time when the larger ones are in the rivers spawning. We have yet to learn how far offshore sturgeons stray. They certainly descend to at least 25 fathoms, for they have been caught on cod and haddock lines at that depth in Scandinavian waters.

The sturgeon is a bottom feeder, most abundant on sandy ground (such, at least, being the case in the North Sea), swimming slowly to and fro when at peace but capable of darting ahead like an arrow on occasion, and frequently coming up to the surface to jump clear of the water. Though so sluggish that it usually offers no resistance when netted, large ones are very strong. An old North Sea proverb has it that leaping sturgeons and dancing girls are both hard to hold!

The adult sturgeon is a mud grubber, rooting in the sand or mud with its snout like a pig (the barbels serving as organs of touch), as it noses up the worms and mollusks on which it feeds and which it sucks into its toothless mouth with considerable amounts of mud. It also consumes small fishes, particularly sand launce. Small ones, while living about estuaries and river mouths, subsist on amphipod and isopod Crustacea. Sturgeon, like salmon, eat little or nothing when running upriver to spawn.

THE EELS. FAMILIES ANGUILLIDÆ, SYNAPHOBRANCHIDÆ, LEPTOCEPHALIDÆ, SIMENCHELYIDÆ, AND NEMICHTHYIDÆ

Eels have no ventral fins; scales are either absent or so small as to be hardly visible; their fins are soft without spines; the gill openings are very small; the vertebræ extend in a straight line to the tip of the tail; and a single fin runs over the back and forward on the belly with no separation into dorsal, caudal, and ventral portions. There are several other fishes of eel-like form in the Gulf of Maine, viz, the hags and lampreys, rock eel (Pholis), snake blenny (Lumpenus), wrymouth (Cryptacanthodes), eel pout (Zoarces), and sand eel (Ammodytes), but the jawless, sucker-

[64] Prince records a 6-inch sturgeon from Hudson Bay (Report of the sixty-seventh meeting of the British Association for the Advancement of Science, held at Toronto in August, 1897, p. 687).

like mouth of the first two separates them at a glance from the true eels, while in all the rest either there is a well-marked separation between anal and caudal fins, ventral fins (large or small) are present, or the dorsal fin is spiny, not soft.

Only four true eels are known from the Gulf of Maine: The common eel (p. 78), the slime eel (p. 83), the conger (p. 86), and the snipe eel (p. 88), which fall into four different families according to American usage. Most European students, however, put the first three (with many other species) into one family (the Anguillidæ), and the snipe eel and its relatives in a second (the Nemicthyidæ). A fifth species, the long-nosed eel (a deep-water form), is to be expected in the deepest parts of the Gulf though it has not been recorded there as yet. The group likewise includes the tropical morays and sundry deep-sea forms, some of them exceedingly bizarre in appearance.

Common, conger, and slime eels look much alike, but are separated from one another by the size of the mouth and by the relative lengths of the fins. In the snipe eels the two jaws are prolonged into a very long slender beak, recalling that of a silver gar, the tail is whiplike, the neck noticeably slimmer than the head, and the general form extremely slender.

KEY TO GULF OF MAINE EELS

1. Both jaws are prolonged into a long slender bill ..... Snipe eel, p. 88
   The jaws are not bill-like, the snout being short and blunt 2
2. The anal fin originates well in front of the point of origin of the dorsal ..... Long-nosed eel, p. 84
   The anal fin originates behind the point of origin of the dorsal 3
3. The dorsal fin originates far behind the tip of the pectoral ..... Common eel, p. 78
   The dorsal fin originates close behind the tip of the pectoral 4
4. Mouth large, gaping back as far as the middle of the eye; very strong and active ..... Conger, p. 86
   Mouth small, falling short of the eye; soft, slimy, and feeble ..... Slime eel, p. 83

32. **Eel** (*Anguilla rostrata* LeSueur)

AMERICAN EEL; COMMON EEL; SILVER EEL; FRESH-WATER EEL

Jordan and Evermann (*A. chrysypa* Rafinesque), 1896–1900, p. 348.

Description.—In the common American eel the dorsal fin originates far behind the pectoral, this character being of itself a sufficient field mark to distinguish it from the conger, from which it also differs in that the lower jaw projects beyond the upper or at least equals it in length, and that its eyes are small and round. Furthermore, it develops scales after it is about 3 or 4 years old, though these are so small that they might be overlooked. Like the conger, however, it has a pointed snout, a large mouth gaping back to or past the middle of the eye, and gill slits set horizontal on the sides of the neck, their upper corners abreast of the center of the base of the pectoral fin. It is very closely related to the European eel (*Anguilla vulgaris*), but has fewer vertebræ (about 107 as compared with about 114 or 115).

Size.—Eels are said to grow to 4 feet in length and to 16½ pounds in weight. Full-grown females average only about 2 to 3½ feet, however, and males are smaller. Any eel more than 18 inches long would probably be a female, and one more than 24 inches in length would certainly be one.

Color.—The color varies widely with the bottom on which the eel lives. As a rule it is dark muddy or olive-brown above, more or less tinged with yellow on the sides; the lower surface paler brown and yellower, with dirty yellowish-white belly.

General range.—The area of distribution of the eel is peculiar. It lives most of its life and makes most of its growth in the estuaries and fresh rivers tributary

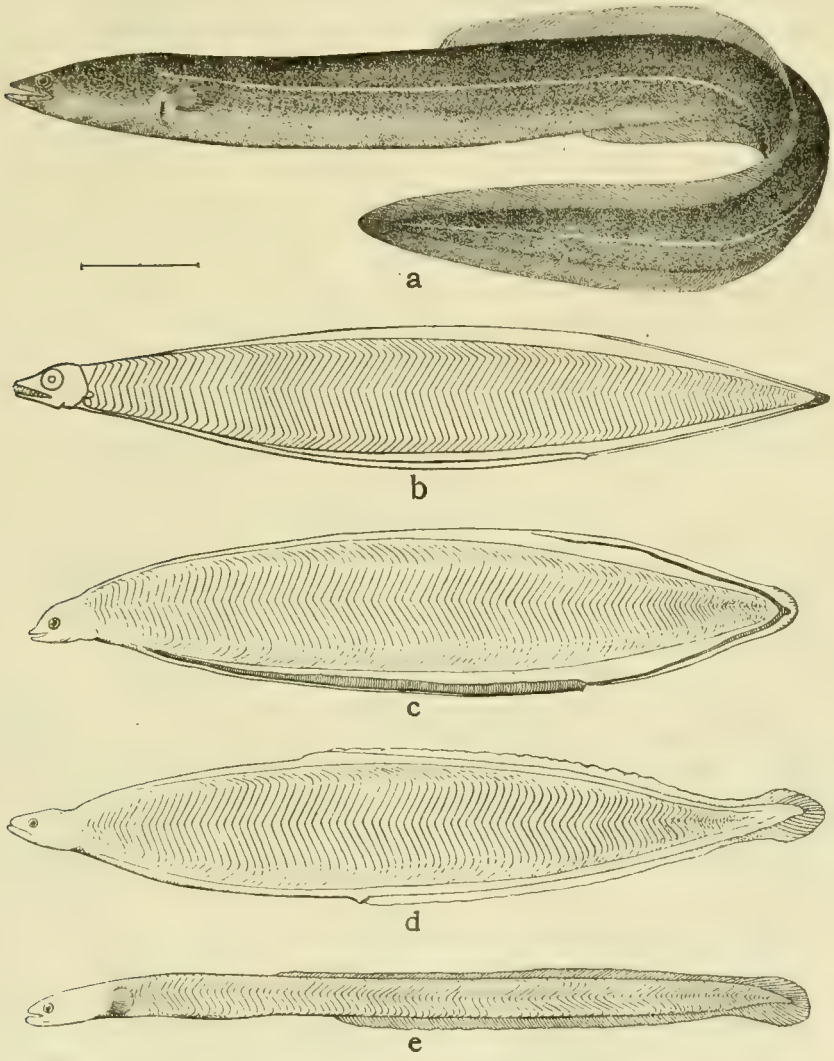

FIG. 33.—Common eel (*Anguilla rostrata*)

a, Adult. *b*, Leptocephalus stage, 49 millimeters. *c*, Leptocephalus stage, 55 millimeters. After Schmidt. *d*, Leptocephalus stage, 58 millimeters. After Schmidt. *e*, Transformation stage, 61 millimeters. After Schmidt.

to the east coast of America, from the Gulf of St. Lawrence south to the Gulf of Mexico and to Brazil, and is common in the West Indies and at Bermuda. It moves out to sea to spawn, however, as described hereafter (p. 81).

Occurrence in the Gulf of Maine.—The occurrence of the eel around the periphery of our Gulf can be described in the one word—"universal." From Cape Sable on the east to Cape Cod on the west there is, we believe, not a single stream mouth, muddy estuary, or tidal marsh into which fresh water empties but supports eels to some extent. They run up every stream, large or small, from which they eventually find their way into the ponds at the headwaters unless barred by insurmountable barriers such as very high falls. Eels are even caught in certain ponds without outlets.

Habits.—Up to very recently the life history of the eel remained a mystery, for although the fact that the young "elvers" run up into fresh water in spring while adults journey downstream in autumn has been common knowledge for centuries, and while a host of myths grew up to explain the utter absence of ripe eels of either sex, either in fresh water or along the seacoast, it was not until a few years ago that the riddle of its breeding place was solved. Now we know that both the American and the European eel lives a life that is just the antithesis of that of the salmon, shad, or alewife, and, thanks chiefly to the persevering researches of the Danish scientist, Johannes Schmidt, the spawning grounds of both eels have been discovered and the history of their larvæ traced.[65] Briefly, the life history of the eel is as follows:

The young "elvers" appear along our shores in spring when they average from 2 to 3½ inches in length. As yet we have little data on the exact date of arrival, but they have been taken as early as March at Woods Hole and in April in Passamaquoddy Bay. The fact that elvers run up the streams emptying into Narragansett Bay from mid-April until mid-May, and that Welsh observed a tremendous run in Little River, near Gloucester, on May 5, 1913, suggests that they may be expected in the mouths of most Gulf of Maine streams late in spring. In the Bay of Fundy region, however, probably owing to the dilatory warming of the local streams, they are found ascending streams during the summer. The run in one stream may last for a month or more, while it may last only for a few days in another. Even at this early stage there is a noticeable habit of segregation, some remaining in tidal marshes and other estuarine situations while many go into fresh water, and some of them ascend the larger rivers for tremendous distances. It is now generally believed that only the females run up above the head of tide—that is, that any eel caught in fresh water is a female—but the evidence on which this assumption rests is none too conclusive, especially in the case of the American eels.

It is no wonder that the ability of the elvers to surmount obstacles on their journey upstream is proverbial, for they clamber over falls, up dams, etc., and even work their way up over damp rocks as Welsh saw them doing in Little River, where they were so plentiful on May 5 and 7, 1913, that he caught 1,500

[65] The life history of the eel is presented in more detail than is possible here by Schmidt (Philosophical Transactions, Royal Society of London, Series B, Vol. CCXI, 1922 (1923), pp. 179–208, summarized in Nature, Vol. CX, July–December, 1922, p. 716), and by Cunningham (Nature, Vol. CXIII, January–June, 1924, p. 199). See also Schmidt (Rapports et Procès-Verbaux, Conseil Permanent International pour l'Exploration de la Mer, Vol. V, No. 4, 1906, pp. 137–204, pls. 7–13), and for a popular exposition of the subject, Smith (National Geographic Magazine, Vol. XXIV, No. 10, October, 1913, p. 1140).

in one scoop of a small dip net and 545 with a few "grabs" of his bare hand. Elvers in equal multitudes have often been described in other streams—American as well as European. Eels can live out of water so long as to give rise to the story that they often travel overland, but there is no positive evidence for this, which leaves their presence in certain ponds having neither outlet nor inlet (a fact often attested) something of a mystery.

In a general way it is true, as has so commonly been said, that eels seek muddy bottom and still water, but this is not always so, as large ones are only too common in swift-flowing, sandy trout streams on Cape Cod. The fact is that they can live and thrive wherever food is to be had, and they are at home in high temperatures as well as in low ones. Occasionally an eel is caught off the open coast, but this is unusual.

No fish is more omnivorous than the eel; no animal food, living or dead, is refused, and its diet in any locality depends less on choice than on what is available. Small fish of many varieties, shrimps, crabs, lobsters, and smaller Crustacea, together with refuse of any kind—for they are scavengers—make up the bulk of the diet in salt estuarine and brackish water. Being very greedy, any bait will do to catch an eel. As every fisherman knows, they are chiefly nocturnal in habit, usually lying buried in the mud by day to venture abroad by night, but eels, large and small, are so often seen swimming about and so often bite the hook by day that this can not be laid down as a general rule.

Although very rapacious, the eel grows slowly, the winter rings on its scales (these do not appear until it is 3 or 4 years old—one larval year and two or three in fresh water) having shown that in the case of the European species full grown adults are from 5 to 20 years old, depending on food supply, etc. This is corroborated for the American species by the fact that Dr. H. M. Smith, former Commissioner of the United States Bureau of Fisheries, found a female on the way down the Potomac to be in her twelfth year. The smallest mature males are about 11 to 12 inches long; females 18 inches long. When fully grown, the female eels, traveling mostly at night, drop downstream at the approach of sexual maturity, which takes place in the fall. They and the maturing males that have been living in the river mouths, bays, and estuaries now cease feeding; the color of the back changes from olive to almost black, while the ventral side turns silvery and the eyes of the males grow to twice their previous size. Both males and females then move out to sea. It is not until after they reach salt water that the ovaries mature. In fact no perfectly ripe female eel and only one ripe male (of the European species) has ever been seen. So little is the life history of the eel understood by our fishermen that we wish again to emphasize the undoubted fact that *no eel ever spawns in fresh water.*

The eel drops wholly out of sight when once it leaves the shore;[66] no one knows how deep it swims—whether singly or in companies—but it certainly

[66] Large eels, on their seaward journey, have occasionally been caught by otter trawlers in the western part of the British channel, but we know of no such occurrence on this side of the Atlantic.

journeys out beyond the continental slope into the oceanic basin before depositing its eggs. From the captures of its youngest larvæ Schmidt has been able to outline the chief spawning center of the American species as from latitudes 20° to 30° N. and from longitudes 60° to 78° W.—that is, east of Florida and the Bahamas and south of Bermuda, while it may spawn (always in deep water) much farther north.

Our eel spawns in midwinter, thus occupying one to two months in its journey from the coast to the spawning ground, for Schmidt found very young larvæ (7 to 8 mm.) in February. Eels, like Pacific salmon, die after spawning, the evidence of this being that no spent eels have ever been seen and that large eels have never been known to run upstream again. Smith suggests that they probably jellify and disintegrate, as does the conger. Eel eggs have not been seen, but certainly they are provided with an oil globule, as this is present both in unripe ovarian eggs and in the vestiges of the yolk sac of the youngest embryos. Eels (European) are among the most prolific of fish, ordinary females averaging five to ten million eggs and the largest ones certainly fifteen to twenty million. The larval, so-called "leptocephalus" stage (figs. 33*b*, *c*, and *d*), as with all eels, is very different in appearance from the adult, being ribbonlike and perfectly transparent, with small pointed head and very large teeth, though it is generally believed that it takes no food until the time of metamorphosis. These leptocephali, which live near the surface, have been found off our coasts as far north as the Grand Banks, but never east of longitude 50°. Inasmuch as the breeding areas of the American and European eels overlap, not the least interesting phase of the lives of the two is that the larvæ of the American species should work to the western side of the Atlantic and the European to the eastern side, and that no specimen of the former has ever been taken in Europe or of the latter in America.

The American species takes only about a third as long as the European to pass through the larval stage, that is, hardly a year as against two to three years. The leptocephali reach their full length of 60 to 65 mm. by December or January, when metamorphosis to the "elver" takes place, in which the most obvious changes are a shrinkage in the depth and length of the body but an increase in thickness to cylindrical form, loss of the larval teeth, and total alteration in the aspect of head and jaws, while the digestive tract becomes functional. It is not until they approach our shores, however, that the adult pigmentation develops or that the elver begins to feed, a change that is accompanied by a *second* decrease in size. How such feeble swimmers as the leptocephali find their way in to the neighborhood of the land remains a mystery. It seems certain, however, that all the young eels bound for the Gulf of Maine complete the major part of their metamorphosis while still far offshore, not only because we have never taken a leptocephalus in the Gulf of Maine in all our tow-nettings, but (and this is more significant) because the *Albatross* towed three young eels in the so-called "glass eel" stage, 54 to 59 mm. long—that is, of practically adult form but still transparent—during her spring cruise in 1920, one of them on Georges Bank, March 11; a second on Browns Bank, April 16; and one in the western basin of the Gulf off Cape Ann, February 23. Evidently they

were intercepted on their way in to land, and since all three were on the surface we may take it that "glass eels," like leptocephali, keep to the uppermost water layers during their journey.

Schmidt has suggested that the American eel is not as plentiful in actual numbers as the European, arguing from the facts that its larvæ have not proven so common on the high seas and that the American catch of eels (about 2,000 tons) is but a fraction as large as the European catch (10,000 tons annually). It is not safe to draw any conclusions from the statistics, as the American catch is limited more by the fact that eels are not much in demand than by the available stock. Eels are regularly caught in numbers in muddy bays and in estuaries at the mouths of rivers all along the shores of the Gulf, the catch for 1919 being as follows:

	Pounds
Nova Scotia shore	16, 700
New Brunswick	8, 000
Coast of Maine	305, 050
Coast of New Hampshire	2, 000
Massachusetts (including south shore of Cape Cod to Buzzards Bay)	239, 991

This suggests a total of about 400,000 pounds for the Gulf of Maine. The greater part of the catch is made by nets and eelpots, with spears a close second, eel spearing being carried on chiefly in late autumn and winter in tidal creeks and marshes.

FIG. 34.—Slime eel (*Simenchelys parasiticus*)

33. **Slime eel** (*Simenchelys parasiticus* Gill)

SNUB-NOSED EEL

Jordan and Evermann, 1896–1900, p. 349.

Description.—The most diagnostic characters of the slime eel—its eel-like form, snub nose, long dorsal fin, and sliminess—have already been mentioned (p. 78). It is stouter and more sway-bellied than the common eel, very soft, and with a more tapering tail. The dorsal fin originates a very short distance behind the tip of the pectoral when the latter is laid back against the body, and the anal runs forward on the lower surface almost to the vent, which is situated about midway of the body. The head is much shorter than in either eel or conger; the mouth very small, gaping back

only about half way to the forward edge of the eye, with upper and lower jaws of equal length and each armed with a single series of small, close-set cutting teeth. The gill openings are very small, and instead of being transverse and on the sides of the neck as in the common eel they are longitudinal and lower down on the surface of the throat.

Size.—About 2 feet long.

Color.—Dark brown, with belly but little paler than back, though usually more or less silvery.

General range.—The continental slope and slopes of the offshore banks, from abreast of the eastern end of Long Island to the Newfoundland Banks, in depths ranging from 200 to more than 900 fathoms; also in deep water about the Azores.

Occurrence in the Gulf of Maine.—So far as we can learn there is no definite record of the snub-nosed eel actually within the southern rim of the Gulf. Our only first-hand experience with it was on the slope south of Nantucket lightship in July, 1908, where we captured 21 in the Monaco deep-sea trap in 455 fathoms. It must be extremely abundant along that zone, however, for so many to find their way into the trap in as short a set as two hours. It has been recorded so often in water as shoal as 200 fathoms that it may be expected in the bottom of the Eastern Channel and in the southeastern deeps of the Gulf of Maine.

FIG. 35.—Long-nosed eel (*Synaphobranchus pinnatus*)

Habits. –It is partly parasitic in habit, burrowing into the bodies of halibut and other large fish, under which circumstances a considerable number of specimens have been brought in by fishermen. Very likely it was common inshore in old days when halibut were plentiful there. It also lives independently on the bottom. Beyond this little is known of its manner of life and nothing of its breeding habits. We may add from experience that it is as slimy as a hag –dripping with sheets of mucus when drawn out of the water.

34. **Long-nosed eel** (*Synaphobranchus pinnatus* Gronow)

Jordan and Evermann, 1896–1900, p. 351.

Description.—This deep-sea species is a typical eel in general appearance but is readily identifiable by the facts that while its dorsal fin originates about as far back, in relation to the length of the fish, as in the common eel (p. 78), its point of origin is behind the vent instead of in front of it, and that the anal fin originates considerably in front of the dorsal fin instead of behind it, as is the case in all other Gulf of Maine eels. Furthermore, its mouth is much wider, gaping far back of the eye, and its snout is pointed. The most interesting anatomic characteristic of this

eel is that its gill openings, which open longitudinally on the lower side of the throat (in the common eel and in the conger they are situated on the sides of the neck), join together at the front end to make what apparently is a single V-shaped aperture, though actually they are separate within.

Color.—Described as uniform brown, darkest below, with the vertical fins darker behind, pale-edged in front, and the inside of the mouth blue black.

Size.—The largest of 89 specimens measured by Goode and Bean (1883, p. 187) was nearly 22 inches (545 mm.) long, the smallest about 9 inches (221 mm.) in length. Collett [67] mentions one 26 inches (675 mm.) in length from the Azores.

General range.—This deep-water species is of very wide distribution, having been taken near Madeira, off Brazil, off Morocco, near the Cape Verdes, about the Azores, and at many localities off the east coast of North America from the Grand Banks of Newfoundland on the north to the latitude of South Carolina; likewise about the Philippines and in Japanese waters. Most of the captures have been from depths of 300 to 1,000 fathoms.

Occurrence in the Gulf of Maine.—This eel has not actually been reported within the geographic limits of the Gulf but is to be expected in the eastern channel and possibly above 150 fathoms along the slopes of Georges Bank, for fishermen have caught them in water as shallow as this off La Have Bank on the one hand, while, on the other, specimens have been trawled in 168 and 129 fathoms off southern New England by the *Fish Hawk* and *Albatross*. So many of them have been brought in by fishermen [68] from deep water off the fishing banks to the eastward of longitude 65°, and so many have been trawled along the continental slope thence westward [69], that this eel must be one of the commonest of fishes below 150 to 200 fathoms from the Grand Banks to abreast of New York.

Habits.—Nothing is known of its habits except that it is a ground fish, that the readiness with which it bites proves it predaceous, and that specimens in spawning condition have been taken in summer.[69] In its development this species passes through a "leptocephalus" stage even more slender than that of the conger (p. 88).[70]

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[67] Résultats des Campagnes Scientifiques du Prince de Monaco, Part 10, 1896, p. 154. Monaco.

[68] Many such instances are listed in the Report of the United States Commissioner of Fish and Fisheries for 1879 (1882), p. 787

[69] Goode and Bean, 1883, p. 187.

[70] The "leptocephalus" larvæ of the long-nosed eel are described and figured by Schmidt (Rapports et Procès-Verbaux, Conseil Permanent International pour l'Exploration de la Mer, Vol. V, No. 4, 1906, Pl. IX, figs. 4–6; and Meddelelser fra Kommissionen for Havundersøgelser, Vol. III, Part 1, 1913, p. 14, pl. 2, figs. 1–4.

35. **Conger** (*Leptocephalus conger* Linnæus)

Sea eel

Jordan and Evermann, 1896–1900, p. 354.

Description.—The readiest characters by which to distinguish the conger from other eels are noted above—notably the origin of the dorsal fin above or only very slightly behind the tip of the pectoral when the latter is laid back, the rather long-pointed snout, the large mouth cleft back at least as far as the middle of the eye, and the scaleless skin. There are also skeletal differences between this and the common eel,[72] and it has many more vertebræ. The conformation of the tip of the snout

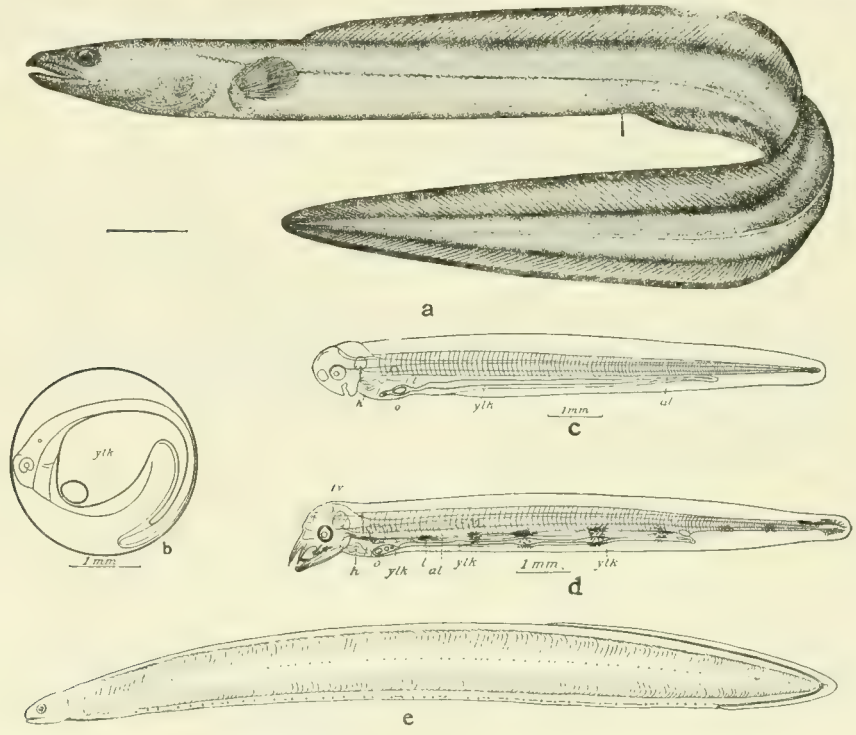

Fig. 36.—Conger eel (*Leptocephalus conger*)

a, Adult *b*, Egg. *c*, Larva, 9 millimeters. *d*, Larva, 10.2 millimeters. *e*, Leptocephalus stage, 142 millimeters. After Schmidt.

likewise serves to identify the conger, for its upper jaw usually projects beyond the lower, whereas in the eel the reverse is true, or at least the lower equals the upper. Furthermore, the eyes of the conger are oval and larger than the round eyes of the common eel. We need only add further, to give an idea of the proportions of the conger, that the distance from tip of snout to dorsal fin is about one-fifth of the total length, the length of the snout one-fourth that of the head, length of pectorals one-third to one-fourth of the distance from the dorsal fin to tip of snout, and that the body is of the snake-like form characteristic of eels in general.

[72] For an account of these see Smitt (Scandinavian Fishes, 1892).

Size.—The female conger grows to an enormous size, certainly to a length of 4½ to 8 feet, the heaviest creditably reported[73] weighing 128 pounds (58 kilos). In European seas 50 to 60 pounders are not unusual, and 25 to 30 pounders are usual, but few of this size are caught off New England. Males are very much smaller, perhaps never more than 2½ feet long. Congers taken near Block Island range from 4 to 6 feet in length; the larger ones taken at Woods Hole usually weigh 8 to 12 pounds.

Color.—Grayish-brown above, sometimes of a reddish tinge, sometimes so dark as to be almost black; paler on the sides; dingy white below.

General range.—The conger is cosmopolitan in the warmer parts of the Atlantic where it is known as far north as Scandinavia on the eastern side and Cape Cod on the western side. It also occurs in the western Pacific and Indian oceans.

Occurrence in the Gulf of Maine.—The Gulf of Maine lies north of the regular range of the conger, which is extremely rare there. The curious bandlike "leptocephalus" larva of the conger has been taken at Cherryfield and at Old Orchard in Maine, and at Nahant in Massachusetts Bay—a total, however, of only six specimens, all of which were collected more than a half century ago—and A. H. Clark, of the United States National Museum, informs us that he found large numbers of leptocephalus larvæ, perhaps belonging to the conger, on the beach at Manchester, Mass., in the summer of 1898 or 1899. The only other positive record for this species in the Gulf of Maine is for North Truro on Cape Cod—whether adult or larva was not stated—nor have we ourselves ever seen or heard of an adult conger north of the cape. It is more plentiful west and south of Cape Cod, being taken at Woods Hole from July into the autumn, and common about Block Island from August until November.[74]

Habits.—Although the conger is rare in the Gulf of Maine its breeding habits are sufficiently remarkable to deserve brief mention. It is now well established that this species, like the common eel, breeds but once during its life and then perishes. Ripe congers are never caught on hook and line, for they cease to feed—hence to bite—for some time previous, but males kept in aquaria have repeatedly been known to become fully ripe, females nearly so,[75] and then invariably dying, the ripening of the sexual products being accompanied by changes in the shape of the head, loss of the teeth, and a jellification of the bones, while the eyes of the males become enormous and the females are much distended by the ovaries. It is probable that the conger ripens off the coast of New England in summer; in captivity they have been known to do so every month in the year except October and November.

The conger, like the common eel, moves out from the coast to spawn, for its young larvæ have never been taken inshore, but if the eggs described below actually belonged to this species, as is generally accepted, then the New England stock travels out only to the edge of the continental shelf for the purpose and does not fare forth to far distant parts of the Atlantic Basin as does the common eel.

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[73] Day: The Fishes of Great Britain and Ireland, Text and Atlas, 1880. London and Edinborough.

[74] Local reports of congers do not necessarily relate to the true conger, for the eel pout (p. 378), which is fairly common in the Gulf, is often misnamed thus.

[75] Cunningham (Journal, Marine Biological Association of the United Kingdom, Vol. II, new series, 1891–92, pp. 16–42) gives an interesting account of this and other phases of the life history of the conger.

The conger is an extremely prolific fish, the number of eggs a female may produce having been estimated as high as from 3 to 6 millions. Conger eggs have never been identified with absolute certainty, but a considerable number of large pelagic eggs towed by the *Grampus* (presumably on the surface) over the tilefish grounds 30 miles south of Nantucket lightship on July 31, 1900, probably belonged to this species, the larvæ hatched from them undoubtedly being eels while the eggs themselves were as certainly not those of the common eel. These eggs (fig. 36b) were 2.4 to 2.75 mm. in diameter with 1 to 6 oil globules, one invariably much larger than the others. They hatched in from two to three days in the Woods Hole hatchery, suggesting a total incubation period of four to five days at the prevailing summer temperature.

It has long been known that the conger, like the common eel, passes through a peculiar ribbonlike larval stage -the so-called "leptocephalus" stage—very broad and thin and perfectly transparent, with a very small head. In fact the first "leptocephalus" ever seen (about 1763) was the larval conger, but although its true identity was suspected it was not until 1886, when the famous French zoologist, Delage,[76] actually reared one through its metamorphosis at the biological station at Roscoff, that the identity of this larva was definitely established. The leptocephalus of the conger is relatively more slender than that of the common eel, and it can always be identified (under a lens) by the fact that its vertebræ and muscle segments are far more numerous (153 to 159 or more, as against only about 107 in the American eel and about 114 in the European eel), and that they grow to a length of 150 to 160 mm.

The duration of the larval period of the conger is not known. The process of metamorphosis consists essentially in a thickening and narrowing of the body, an enlargement of the head, the formation of the swim bladder and the permanent teeth, and the pigmentation of the skin, a change that occupied about two months (May to July) in the case of Delage's specimen. At its completion his young conger was 9.3 centimeters (3.6 inches) long.[77]

36. Snipe eel (*Nemichthys scolopaceus* Richardson)

Jordan and Evermann, 1896–1900, p. 369.

Description.—The snipe eel is made easily recognizable by its extremely slender body (the fish may be 75 times as long as deep), with its tail tapering to a thread, and by its bill-like jaws, which are equally elongate, the upper one curving upward but the lower nearly straight. The head is much deeper than the neck, with a large eye. The dorsal fin originates in front of the pectoral, the anal about abreast of the tip of the latter, and both run back to the tip of the tail. There has been some confusion in the published accounts and illustrations as to these two fins, for while Vaillant[78] shows both about as high throughout their length as the

[76] Comptes Rendus hebdomadaires des séances de l'Academie des Sciences, vol. 103, 1886, p. 698. Paris.

[77] Schmidtlein (Mittheilungen aus der Zoologischen Station zu Neapel, Band I, 1879, p. 135) speaks of young "congers" at Naples in April as hardly one-third as long as this, a discrepancy suggesting that they may actually have belonged to one of the Murænoid eels.

[78] Poissons. Expéditions Scientifiques du Travailleur et du Talisman, Pendant les Années 1880, 1881, 1882, 1883 (1888), Pl. VII, figs. 2 and 2a. Paris.

fish is deep, Goode and Bean (1896, pl. 46, fig. 170) picture the dorsal as much higher than the anal (the artist evidently having transposed the two fins), whereas Brauer [79] represents the anal as approximately twice as high as the dorsal and the latter as soft rayed in its anterior and posterior portions but composed of short thornlike spines over its central third. In two specimens taken off New England and now in the collections of the Museum of Comparative Zoology the fins are as follows:

Dorsal, soft rayed and nearly as high as the body is deep for its first half; back of that it consists of a series of very short, stiff rays that extend to the tip of the tail.

Anal, soft-rayed throughout its length and about as high as the body is deep, tapering to almost nothing on the tail.

In part the confusion has been due to the rather fragmentary state in which these deep-water fish usually arrive on board, but at the same time it is probable that two distinct species have been confused under the name *scolopaceus*, as Brauer

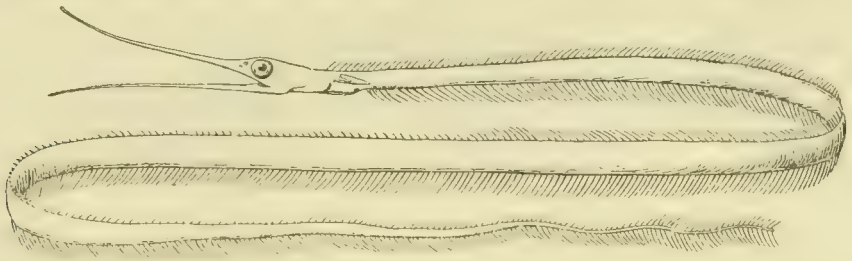

FIG. 37.—Snipe eel (*Nemichthys scolopaceus*)

suspected. Both jaws and the roof of the mouth as well are thickly studded with small sharp teeth.

Color.—Described as pale to dark brown above with the belly and anal fin blackish after preservation. Judging from experience with other deep-sea fishes and from Brauer's plate (which, however, may be another species), we suspect that in life it is chocolate brown above and velvety black below.

Size.—Maximum length about 3 feet.

General range.—The snipe eel has been taken in the South Atlantic, near Madeira, off the Cape Verde Islands, off West Africa, in the Pacific north of New Guinea, and in deep water at many stations off the east coast of North America between latitudes 31° and 42°, longitudes 65° and 75°.

Occurrence in the Gulf of Maine.—One specimen taken from the stomach of a codfish caught on Georges Bank in 45 fathoms is the only Gulf of Maine record, but several have been taken in depths of from 300 to 2,000 fathoms seaward from the bank.

Habits.—Although commonly spoken of as a "deep-sea" fish, this species is undoubtedly an inhabitant of the mid depths, not of the bottom, and judging from the occurrence of other black fishes it probably finds its upper limit at 100 to 200

[79] Die Tiefsee-Fische. Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition, 1898-1899 (1900), Band XV, Teil I p. 126, pl. 9, fig. 1.

fathoms. Nothing further is known of its habits, but Mowbray's [80] recent capture near Bermuda of a snipe eel clinging by its jaws to the tail of a large red snapper has suggested the possibility that this is a regular habit of this curious species.

THE TARPONS AND HERRINGS. FAMILIES ELOPIDÆ AND CLUPEIDÆ [81]

The Elopidæ are very closely allied to the true herrings (Clupeidæ), from which they differ in having an elongate, bony, interjugular plate on the throat between the branches of the lower jaw. There are only about five species, all of them tropical.

The herrings (Clupeidæ) are soft-finned fishes wholly lacking spines, with one short dorsal fin, deeply forked tails, ventral fins situated on the abdomen far behind the pectorals, small teeth, deep compressed bodies, and large scales that slip off at a touch. They are, perhaps, the most familiar of northern sea fishes and certainly are the most abundant in number of individuals. Seven species of herring occur in the Gulf of Maine—the round herring and hickory shad, very rare; the sea herring, alewife, blueback, and shad, regular; and the menhaden, irregular in its occurrence. Among these the round herring, shad, menhaden, and sea herring are named at a glance, but the others resemble one another so closely that they are often confused even by the fishermen who constantly handle them.

KEY TO GULF OF MAINE TARPONS AND HERRINGS

1. Last dorsal ray not elongate 2
   Last dorsal ray elongate ..... Tarpon, p. 91
2. Belly rounded ..... Round herring, p. 91
   Belly compressed, its edge sharp 3
3. Head (tip of snout to edge of gill cover) not more than one-fourth the total length of the fish; free margins of scales rounded 4
   Head very large, occupying nearly one-third the total length of the fish; free margins of scales fluted instead of rounded ..... Menhaden, p. 118
4. Tip of upper jaw deeply notched, inclosing tip of lower when mouth is closed ..... Shad, p. 113
   Tip of the upper jaw is not notched, or, if notched, the lower jaw projects considerably beyond the upper when the mouth is closed 5
5. Edge of the belly is hardly serrated, though sharp; the general form is comparatively shallow; there is a cluster of teeth on the midline of the roof of the mouth. Sea herring, p. 92
   Edge of belly is strongly serrated; general form deep; there are no teeth in the midline of the roof of the mouth 6
6. The lining of the belly is pale gray 7
   Lining of belly is black or dark blotched ..... Blueback, p. 110
7. Head occupies about one-fourth of total length of fish; lower jaw projects considerably beyond upper; general profile tapers toward the rather pointed head as well as the tail ..... Hickory shad, p. 105
   Head occupies hardly one-fifth of total length of fish; lower jaw hardly projects beyond upper; body deep and heavy forward ..... Alewife, p. 107

[80] Copeia, No. 108, July, 1922, p. 49.

[81] The ladyfish (*Elops saurus* Linnæus), a tropical species that would reach the Gulf of Maine as a stray only, has been reported by Halkett (1913, p. 45) at Black's Harbor, Charlotte County, New Brunswick, on the north shore of the Bay of Fundy, but the specimen in question, which was 7 inches long and not in very good condition, differed in some respects from published descriptions of this species, hence its identity is doubtful.

37. **Tarpon** (*Tarpon atlanticus* Cuvier and Valenciennes)

Jordan and Evermann, 1896–1900, p. 409, fig. 177.

Description.—The tarpon is herringlike in general form and appearance, but it is made easily recognizable by the fact that the last ray of the dorsal fin is greatly elongated, its free portion being as long as or longer than the fin is high, and by the presence of the bony interjugular plate mentioned above in the characterization of the family to which it belongs. Furthermore, the anal fin of the tarpon is deeply falcate; that of all Gulf of Maine herrings rhomboid in outline. The ventral fins, which are situated under or behind the dorsal fin in herrings, alewives, shad, and menhaden, are considerably in front of the dorsal fin in the tarpon, while the lower jaw of the latter projects relatively further, its scales are relatively larger, and its caudal fin is relatively wider.

FIG. 38.—Tarpon (*Tarpon atlanticus*)

Color.—Bright silvery all over, the back darker than the belly.

Size.—Tarpon grow to a length of 6 to 8 feet (longest recorded, 8 feet 2 inches).

General range.—Tropical and subtropical coasts of America, from Brazil to Long Island, casually to Cape Cod, and to Nova Scotia, where it has been recorded twice—off Isaacs Harbor and in Harrigan Cove.[82] Its chief center of abundance is in the West Indies, about Florida, and in the Gulf of Mexico.

Occurrence in the Gulf of Maine.—A specimen 5½ feet long, taken at Provincetown on July 25, 1915,[83] is the only record of the tarpon in the Gulf of Maine, which it reaches only as an accidental straggler from the south.

38. **Round herring** (*Etrumeus teres* DeKay)

STRADINE

Jordan and Evermann, 1896–1900, p. 420.

Description.—The most diagnostic feature of this fish among herrings is that its belly is rounded and not sharp edged. It is, furthermore, the most elongate of our herrings, its body being only one-sixth as deep as long, thus suggesting a smelt in its general outline. Its dorsal fin, too, stands wholly in front of the ventrals instead

[82] Halkett, 1913, p. 45.
[83] Radcliffe, 1916, p. 3.

of over the latter, as in herring, alewives, and shad, and there are fewer anal fin rays (only about 13, whereas the herring has about 17, the alewife about 19, and the shad about 21) than any of the latter.

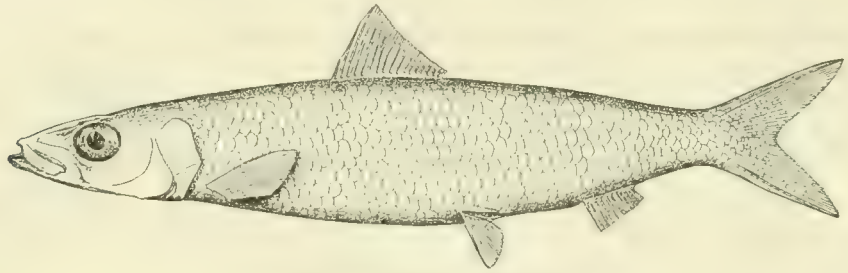

FIG. 39.—Round herring (*Etrumeus tere*

Color.—Olive green above with silvery sides and belly.

Size.—Eight to ten inches.

General range.—Atlantic and Gulf of Mexico coasts of the United States; occasionally common as far north as Woods Hole, but very rarely straying past Cape Cod.

Occurrence in the Gulf of Maine.—The only published Gulf of Maine records for this southern fish are from Eastport, where the newspapers reported it in 1908, and from Jonesport, Me., but the collection of the Museum of Comparative Zoology also contains two specimens from Provincetown.

39. **Herring** (*Clupea harengus* Linnæus)

LABRADOR HERRING; ENGLISH HERRING; SEA HERRING; SARDINE; SPERLING; BRIT

Jordan and Evermann, 1896–1900, p. 421.

Description.—This herring is typical of its family in form, with body so compressed that it is much deeper than thick, moderately pointed nose, large mouth situated at the tip of the snout, and lower jaw projecting beyond the upper, which is not notched at the tip (in shad it is so notched, p. 113), sharp-edged belly, and deeply forked tail. The dorsal fin stands over the small ventrals, its origin about

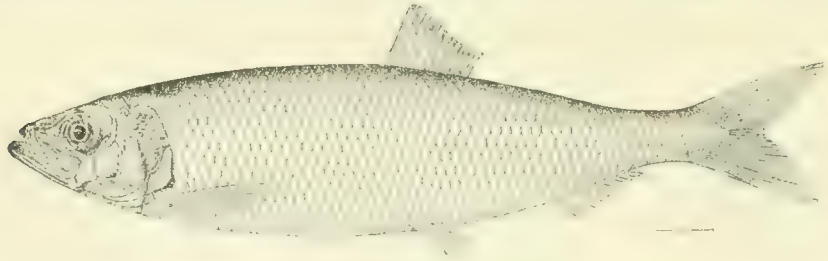

FIG. 40.—Herring (*Clupea harengus*)

midway the length of the body. The scales are large, their rear margins rounded and so loosely attached as to slip off at a touch. There is no adipose fin, its absence at once distinguishing herrings from any of the salmon tribe. The dorsal and anal

fins have no true spines nor is there a lateral line. The anatomical character separating the sea herring from the several alewives (genus Pomolobus) is the presence of an oval patch of small teeth on the vomer bone in the center of the roof of the mouth in the former, but even without this test a practiced eye can separate herrings from alewives at a glance by the comparatively shallow bodies of the former and the deeper outlines of the latter, a difference better shown in the illustrations. Furthermore, the sharp midline of the belly is but weakly serrate in the herring, while in the alewives it is saw-toothed.

Size.—Herring grow to a length of about 17 inches.

Color.—Deep steel blue or greenish blue on the back with green reflections; the sides and belly silvery; the change from dark belly to pale sides often marked by a greenish band. The gill covers sometimes glisten with a golden or brassy gloss; indeed, fish just out of the water are iridescent all over with different hues of blue, green, and violet, beauties that soon fade, however, leaving only the dark back and silvery sides. The ventral and anal fins are transparent white; the pectorals, however, are dark at the base and along the upper edge; the caudal and dorsal dark grayish or shading into green or blue.

General range.—Both sides of the North Atlantic. Off the European coast the herring ranges north to Norway, Spitzbergen, and the White Sea, as well as to Iceland and Greenland; south to the Straits of Gibraltar. On the American coast it is known as far north as northern Labrador; regularly and commonly as far south as Block Island, though most abundant north of Cape Cod; and it is occasionally seen at Cape Hatteras in winter. It is replaced by a close ally (*C. pallasii*) in the North Pacific.

Occurrence in the Gulf of Maine.—The herring is probably the most numerous fish in the Gulf of Maine as it is in the North Atlantic generally. To list the localities where it has been recorded would be to mention every hamlet along the coast from which fishing boats put out, for it is universal at one season or another around the whole coast line of the Gulf as well as offshore. Off most parts of the coast, however, the appearance of schools of herring, large or small, is distinctly a seasonal phenomenon, and inasmuch as its on and off shore migrations are intimately bound up with the phenomena of reproduction and growth a brief consideration of these may precede the more detailed discussion of its occurrence.

Breeding habits.—So much study has been devoted to the natural history of the herring by European zoologists, as well as by Moore (1898) and Huntsman (1919, and unpublished notes) in our own Gulf, and by Lea [84] in more northern Canadian waters, that we have very good knowledge of its breeding habits in general and of its early growth. This may be briefly summarized as follows:

It has long been known that the eggs of the herring sink to the bottom, where, by means of their coating of mucus, they stick in layers or clumps to the sand or clay, seaweeds, stones, or any other objects they chance to settle on. They are often found massed on net warps, anchors, and anchor rodes. The eggs are 1 to 1.4 mm. in diameter, depending on the size of the parent fish and also, perhaps, on the local race of fish involved. Females—again according to their age and size—

[84] Age and growth of the herrings in Canadian waters. Canadian Fisheries Expedition, 1914–15 (1919) pp. 75–164.

deposit from 20,000 to upwards of 40,000 eggs, averaging about 30,000. In sexually mature herrings, just before spawning commences, the genital organs are so large as to make up about one-fifth the total weight of the fish. The period of incubation is governed by temperature—European students tell us that it requires as long as 40 days at 38.3° F., 15 days at 44° to 46° F., and 11 days at 50° to 51° F., while experiments on the Massachusetts coast by the U. S. Bureau of Fisheries gave 10 to 12 days in the temperature prevailing there in autumn. Ten to fifteen days might be stated as an average for the Gulf of Maine.

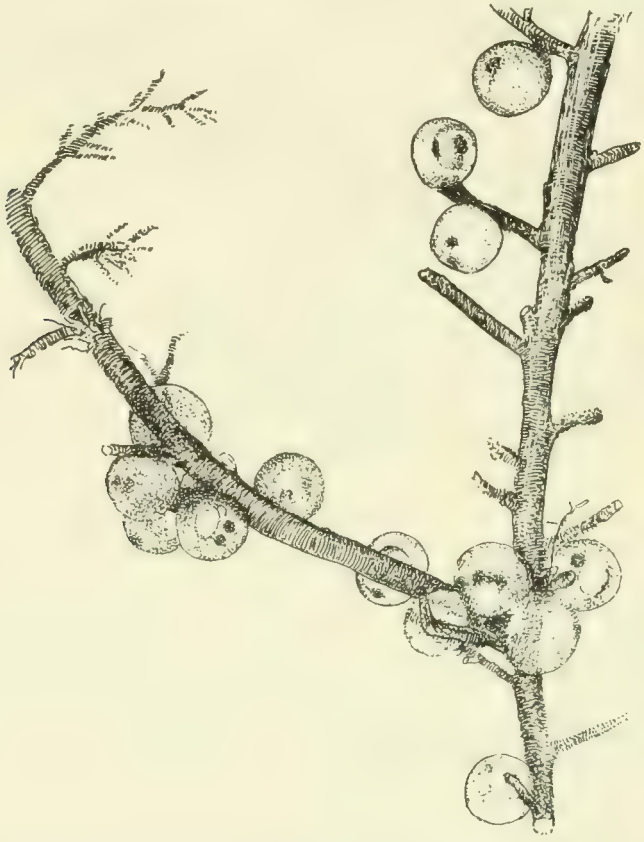

FIG. 41.—Eggs of the herring (*Clupea harengus*) attached to seaweed. After Ehrenbaum

Spawning grounds in the Gulf of Maine.—Herring spawn all along the shores of the Gulf of Maine wherever the bottom is suitable, from Grand Manan on the east to Cape Cod on the west, as well as along the western shores of Nova Scotia, as, for instance, about the Trinity Ledges (an important breeding ground), though whether as universally there we have not been able to learn. Probably the most productive spawning ground within the limits of the Gulf is at the mouth of the Bay of Fundy, particularly about Grand Manan. At present, according to Huntsman, herring spawn only locally, e. g., at Minas Basin, in the inner part of the bay.

From there westward the presence of spawning herring has been recorded in Machias Bay, about Jonesport, at Mount Desert, in Frenchmans Bay, among the islands at the mouth of Penobscot Bay (Swans, Isle au Haut, and Matinicus [85]), in Casco Bay, and especially about Wood Island, a few miles south of Cape Elizabeth, which has long been known as the resort of tremendous breeding schools. Herring also spawn off the beaches along the western shore of the Gulf—Ipswich Bay, for example, about Cape Ann, in Massachusetts Bay, about Provincetown, along Cape Cod, in the Woods Hole region, near No Mans Land, and about Block Island, which is the southern breeding limit. Spawning takes place both along the shore line and generally on the various reefs and shoals that lie from 5 to 25 miles off the coast of Maine, a habit betrayed by the eggs "that are found adhering to rodes of vessels and boats engaged in the cod and haddock fisheries." [86] Indeed, as Moore suggests, it may well be that a large proportion of the herring of our coasts are hatched on these offshore shoals. We find no definite record of herring spawning on Georges or Browns Banks, nor is it likely that they do so on the muddy bottoms of the deeper basins of the Gulf. Herring spawn chiefly on hard, rocky, pebbly, gravelly, or sandy bottoms, to some extent on clay, and probably never on soft mud.

Depth of spawning.—Herring are not known to spawn in the littoral zone in our Gulf west of Grand Manan (possibly the spring-spawning fish may have done so of old in the Bay of Fundy), nor is the spawn ever cast up on the New England beaches by the surf, a fate that often overtakes it in the Gulf of St. Lawrence. Both in the Bay of Fundy and along the coasts of Maine and Massachusetts eggs are deposited chiefly from a depth of 2 or 3 down to 30 fathoms. While no absolute depth limits can be established it is not likely that our Gulf of Maine herring ever spawn below 75 fathoms (in Scandinavian waters herring occasionally spawn down to even 100 fathoms), for to do so would involve the deposition of the eggs on soft mud bottom, where they would be in danger of smothering.

Season of spawning.—It has long been known that, according to locality, the herring spawn in spring, summer, or autumn, or in both spring and autumn, as, for example, in the Gulf of St. Lawrence, and it is established that both spring-spawning and summer-fall spawning schools of herring formerly existed in the Bay of Fundy. These spring spawners visited both the south (Nova Scotian) side of the bay from Brier Island at its mouth in as far as Digby Gut, and the St. Andrews region on the New Brunswick shore near the mouth of the bay, spawning there during April and May. However, they were never very numerous except in restricted localities and have now vanished, temporarily at least. Spring-spawning as well as autumn-spawning herring were likewise reported to us by the fishermen along the west coast of Nova Scotia, though this we have not been able to verify. Other than this, spring spawners are neither recorded nor rumored anywhere in the Gulf of Maine.

According to Moore the breeding schools arrive in June at Grand Manan, which may fairly be termed the premier spawning ground, to spawn from then until

[85] According to fishermen's reports, says Moore, spawning herring were unknown at Matinicus until 1880; since then the neighborhood has been a productive spawning ground.

[86] Moore (1898, p. 108).

late in the fall, with the heaviest runs in July, August, and the first part of September, though Doctor Huntsman writes that in 1917 the season lasted only from early August to early October. In Machias Bay, near by, herring spawn at about the same season, that is, from mid-July until the end of September. Passing thence westward we find the breeding period progressively later and shorter—mid-August until October about Petit Manan and near Mount Desert; mid-September until the end of October near Casco Bay and off Wood Island; September 20 until about November 1 in Ipswich Bay;[87] the month of October in Massachusetts Bay; while west of

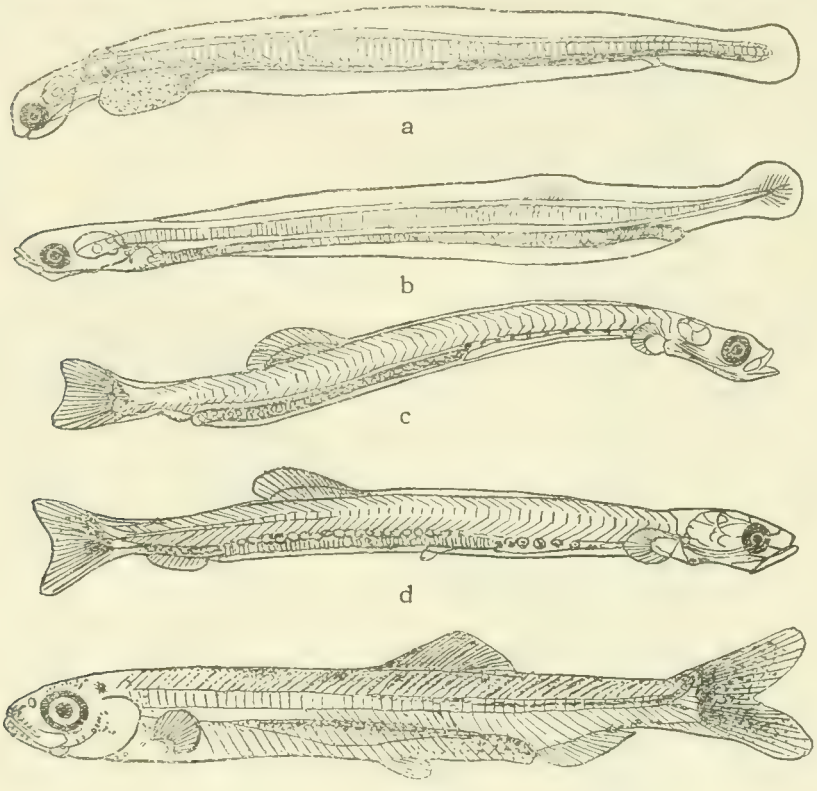

FIG. 42.—Larval stages of the herring (*Clupea harengus*). After Ehrenbaum

a. Newly hatched, 7 millimeters. *b*. 10 millimeters. *c*. 19 millimeters. *d*. 29 millimeters. *e*. Fry, 41 millimeters.

Cape Cod the herring do not begin to spawn until mid or late October, with the major production of eggs about the 1st of November. Thus, while spawning occupies three months at the mouth of the Bay of Fundy it lasts hardly longer than one month in the southwestern part of the Gulf besides commencing some three months later in the year.

Temperature at which spawning takes place.—Thanks to the considerable numbers of serial observations taken in the Gulf by the *Grampus* during the past 10 years and in the Bay of Fundy by the Biological Board of Canada, it is now possible to establish the temperature at which herring spawn in our waters more closely than

[87] Allen. Memoirs, Boston Society of Natural History, vol. 8, No. 2, 1916, p. 201, *fide* E. R. Haskell, of Ipswich, Mass.

Moore was able to do it. Doctor Huntsman has informed us that on the Grand Manan ground (where the temperature is kept practically uniform, vertically, by the violent tides) herring begin spawning when the water warms to about 46° to 47° F. The temperature there rises to only about 48° at 5 to 20 fathoms depth at the height of the breeding season. Near Eastport, too, the average range of temperature from the surface down to 5 fathoms is only about 44.6° to 52° for July, August, and the first half of September, while a comparison of our temperature records with the breeding season at different localities shows that in the northern part of the Gulf practically all spawning is carried out in temperatures of 46° to 52°. In the southern part of Massachusetts Bay and along the shores of Cape Cod, where autumnal cooling of the surface waters is not as rapid as farther north, herring may spawn in slightly warmer water, say up to 53° or 55°. The Gulf of Maine herring spawn in rather low salinities (such, indeed, characterize the coastal zone as a whole as compared with the North and Norwegian Seas), the most saline water in which it is known to spawn within our limits being not salter than 33 per mille, the freshest probably about 31.9 per mille. They never spawn in brackish water within the limits of the Gulf, although known to do so in the almost fresh water of the mouths of certain European rivers.

Larvæ of the herring family are extremely slender and can easily be distinguished from all other young Gulf of Maine fish of similar form (e. g., launce, smelt, or rock eel) by the location of the vent, which is so far back that it lies close to the base of the tail, but it requires critical examination to distinguish our several clupeoids from one another in their early stages.

The sea herring is about 5 to 6 mm. long at hatching, with a small yolk sac that is absorbed by the time a length of about 10 mm. is reached. The dorsal fin is formed at 15 to 17 mm.; the anal at about 30 mm.; the ventrals are visible and tail well forked at 20 to 35 mm.; and at about 40 mm. the little fish begins to look like a herring.

According to Huntsman's observations fry produced on the Grand Manan spawning grounds in late summer and early autumn grow to a length of 17 to 20 mm. by the end of November or first of December, but there is every reason to believe that the rate of growth slackens during the winter season, not only from studies made elsewhere but because we have taken fry only 26 to 50 mm. long in March and April (p. 100), while young herring 50 to 60 mm. long are abundant in the St. Andrews region in June. These yearlings grow to about 90 to 125 mm. at the end of their first year of life, fish of that size, presumably of the previous autumn's hatch, being abundant in the fall of the year in the Bay of Fundy. This works out at an average growth of about 10 mm. per month for the warm half of the year, which corresponds fairly closely with the rate at Woods Hole where, according to Smith, young herring spawned in October and early November are 7 mm. long in January, 25 to 32 mm. in May, 65 to 76 mm. in August, and 76 to 125 mm. in their first autumn. In Norwegian waters, too, according to Hjort, the herring is about 125 mm. long at the end of its first year of life,[88] and North Sea herring are

[88] Huntsman (1919) believed he could recognize spring as well as autumn-spawned herring fry in the Bay of Fundy, and credits them with a length of about 90 mm. by the first and 150 mm. by the second winter. This, however, would seem to call for confirmation, it being unlikely that herring now spawn in the Bay in spring (p. 95).

about 100 mm. long when 1 year old. On the average, then, a yearling is between 3½ and 5 inches long.

Subsequent growth.—The herring has proved a particularly favorable object for age and growth studies based on the structure of the scales, a method of investigation that has led to a great advance in the knowledge of the life histories of many of our important food fishes during the past 20 years So easily are herring scales interpreted, thanks to their distinct summer and winter rings, [89] that confidence can be placed in the age-determinations of the many thousands of herrings that have now been examined and in the correlations between age and size resulting therefrom, this phase being better known for the herring than for any other fish. Without entering into this subject, which would lead us far afield, we may point out that herring not only grow at different rates and that the contrast between the rapid growth of summer and the slow growth of the winter is greater or less in different seas, but that in some localities herring grow rapidly when young and slowly thereafter, while in others they may grow slowly at first but sustain a more even growth to old age, a contrast of this sort obtaining between the herrings of the Magdalen Islands and of the west coast of Newfoundland.[90]

The Dogger Bank herring in the North Sea (to mention a couple of European examples only) approximate 4 inches in length at the end of the first year, 8½ to 9 inches at the end of the third, 10½ inches at the end of the sixth, and 11½ to 12 inches at the end of the ninth year of life, though with considerable variation due, no doubt, to varying food supply and to the general suitability of the conditions under which they live. According to Hjort [91] Norwegian herring spawned in the year 1899 and examined at 10 years of age exhibited the following growth: 3½ inches at 1 year, 7¼ inches at 3 years, 11¼ inches at 6 years, 12½ inches at 9 years, and about 12¾ inches at 10 years. From this it is evident that they did not grow so fast as the North Sea fish at first, but attained the same size at 6 to 9 years of age.

Huntsman (1919) credits the Bay of Fundy herring with about the same growth—4 inches at the end of its first and 10 inches at the end of the third year—as the Dogger Bank fish, making most of their growth from May to September. Probably the growth period lasts a month later in the southern parts of our Gulf. In Norwegian waters it has been found that herring grow from April to September only, remaining practically stationary in length from October until March.[92]

Size at maturity.—According to Moore, who examined thousands of fish about Eastport, herring rarely spawn when less than 9½ inches long, usually not until they are 10 to 10½ inches, with most of the spawners 12 to 13 inches long. This he interpreted to mean that some few spawn when only 2 or 3 years old—most of them, however, first at 4 years or older—to continue spawning annually

[89] See Einar Lea (Age and growth of the herrings in Canadian waters. Canadian Fisheries Expedition, 1914-15 (1919,) pp. 75-164) for an account of age-determination by analysis of the scales, as it applies to the herring.

[90] Hjort, Canadian Fisheries Expedition, 1914-15 (1919), pp xi-xxviii, and Lea, *Ibid*, pp. 75-164

[91] Conseil Permanent International pour l'Exploration de la Mer, Rapports et Procès-Verbaux, Vol. XX, 1914, 228 pp. 3 pls. Copenhague.

[92] Lea, Einar: A study on the growth of herrings. Conseil Permanent International pour l'Exploration de la Mer, Publications de Circonstance No. 61 (1911), pp. 37-57. Hjort, Johan: Fluctuations in the great fisheries of northern Europe, viewed in the light of biological research. Conseil Permanent International pour l'Exploration de la Mer, Rapports et Procès-Verbaux, Vol. XX, 1914, 228 pp., 3 pls. Copenhague.

thereafter as long as they live. In Norwegian waters, too, a few spawn at 3, many at 4, and the majority at 5 years of age and upwards; some few, indeed, not until 6 years. Herring as old as 20 years have been seen, and they may live even longer.

Success of reproduction.—The maintenance of the stock of any fish and its relative abundance from year to year depends less on how many fish spawn in any locality than on how many of the resultant fry survive. The many age analyses made of herring of different sizes and from various seas have proven that while in some years a very large crop of young fish is produced, in others hardly any are obtained even in favorable nurseries. Apparently this applies more to the northern than to the southern breeding grounds—to some extent, however, to all—the result being that the fish spawned in some one favorable breeding season may dominate the herring schools over large areas for many years or until another good breeding year produces another large crop. In Norwegian waters, for example, few herring were raised in 1903 but so many were produced in 1904 that fish of that year predominated in the catches for the next six years at least.

Unfortunately information along this line is yet unavailable from the Gulf of Maine.[93] No doubt similar fluctuations occur in the crop there, too, for Lea[94] found that fully 50 per cent of the herring taken at West Ardoise and Lockport on the outer coast of Nova Scotia in 1914 belonged to the year-class spawned in 1911, whereas on the west coast of Newfoundland fish hatched in 1904 dominated the spring catches of 1914 and 1915. Various explanations, such as abundance or scarcity of microscopic plankton, favorable or unfavorable temperature or salinity, etc., have been proposed to account for this, all of which may enter in, for while it is during the first few weeks of life that the herring is most vulnerable it is also possible that the conditions under which the parent fish lived for the year preceding spawning may influence the fate of the fry. Whatever the explanation, the fact that such fluctuations do occur from year to year in the stock of fry reared is of the greatest practical interest to all concerned with the sea fisheries, as evidence that variations existing in the stock of herring, and consequently in the catch, are due more to the success or failure of reproduction than to depletion by over fishing.

Seasonal movements of herring in the Gulf of Maine.—The life of the herring may be divided, roughly, into three stages correlated with differences in distribution and seasonal movements. First, the young and "sardine"; second, the immature "fat"; and third, the mature "spawn." When the little herring reach an age of about 2 years and a length of 190 to 200 mm. they begin to accumulate large amounts of fat among the body tissues and viscera during their period of active growth in the warm months of the year, and lose this fat in winter and at the approach of sexual maturity. We can bear witness—the fact is well known to fishermen—that the "fat" stage is as characteristic of American waters as of European, where "fat" herring are the objects of extensive fisheries.

Owing to the fact that most of the herring larvæ hatch and pass the first couple of months of their existence at a time of year (September to February) when we

[93] Herring studies had been one of Mr. Welsh's major undertakings.

[94] Canadian Fisheries Expedition, 1914-15 (1919), p. 131, fig. 38.

have made few hauls in the coastal waters of their nativity, we have taken very few smaller than 20 mm. long in our tow nets. The largest catch was in Gloucester Harbor where larvæ of only 9 to 11 mm. (spawned but a few weeks previous) swarmed on October 24, 1916. Huntsman, however, has been able to follow the migrations of September-spawned herring off Grand Manan,[95] his general and we believe justifiable conclusion being that for a short time the larvæ are carried passively in the water, resulting in a drift to the southwest, with the set out of the Bay of Fundy, at a rate of about 2 miles per day, but that they turn back and make headway against the current (technically become "contranatant") when no more than 18 mm. long.[96]

Probably the young herring sink down into the water a few fathoms deep during their first winter to escape the extreme chilling of the surface stratum, while our tow nettings afford evidence that before the following spring they become very widely dispersed over the Gulf, for during March and April of 1920 we took odd specimens at localities as generally distributed as the neighborhood of Cashes Ledge, the northern and eastern parts of Georges Bank, the north Channel, off Seal Island and Yarmouth (Nova Scotia), off Lurcher Shoal, off Machias, Me., both near land and out over the deep basin, near Boothbay, and near the Isles of Shoals. It is probable, however, that the majority of any particular body of fry hatched together remain near their birthplace, for not only may little herring be taken just outside the Bay of Fundy in winter (though they desert its estuaries then), but they reappear, grown to a length of 2 to 3 inches, along our entire shore line in myraids with the advent of spring. This reappearance takes place about the middle of April—sometimes as early as the last of March—in Massachusetts Bay; in April and May along the eastern coast of Maine, in the Bay of Fundy, and on the west coast of Nova Scotia. East of Penobscot Bay generally, and particularly about the mouth of the Bay of Fundy, "sardine" size herring from 3 to 8 inches long, including 1 and 2 year olds, may be expected in abundance all summer, though the schools wander and are so local in their appearances and disappearances that they may swarm in one bay while sought in vain a few miles away. In the southwestern part of the Gulf, however, as exemplified by Massachusetts Bay, it is probable (though not yet proven) that yearlings do not appear until several months later than the fish of 2 to 3 inches hatched the preceding autumn, for while these are reported as more or less abundant throughout the spring,[97] especially in such partially inclosed waters as Provincetown Harbor and Plymouth and Duxbury Bays, they apparently move out again during the early part of summer, being far less plentiful in June than in April and May, and it is not until late July or August that "sperling" of 5 to 7 inches (fish in their second summer) appear in numbers off the Massachusetts coast.

Even in a region as small as Massachusetts Bay wide local variation obtains in the abundance and time of appearance of the "sperling." At Provincetown, for example, they may be expected in schools plentiful enough to be worth "torching"

[95] Doctor Huntsman allows us to quote from unpublished notes.

[96] This requires confirmation, as Doctor Huntsman remarks in his notes.

[97] Being too small for bait, and there being no sardine factories on Massachusetts Bay, no attention is paid to the smallest herring there, and consequently little is known about them during their first spring and summer.

any time after mid-July. At Cohasset, however, near the head of the Bay, this seldom happens before September, but we ourselves have seen "sperling" very plentiful there, singly and in small companies, in July and August.

During the autumn these two year classes (the fish in their first year have grown to a length of 3 or 4 inches; those in their second year to 7 to 9 inches by September) together with the large spawning adults are very abundant all around the shore line of our Gulf, but they begin to thin out after the middle of October, and when winter sets in the fish that are then 1 and 2 years old move out into deeper water once more, few being taken after early December. Probably they winter mostly on the bottom, for schools are very seldom reported on the surface then, but there is no reason to suppose that the bulk of them travel far, for herring of all sizes are to be found in the Bay of Fundy all winter and are even caught occasionally in the weirs near Eastport as late as February, being seen again as early as March and April.

It is during the third summer, when the Gulf of Maine herring is past the "sardine" or "sperling" stage and has not yet reached spawning age, that least is known about its movements. It is now "fat" and termed a "sea" or "summer" herring locally. Our "fat" herring lie offshore more than do the younger fish, and although numbers of them are taken in the weirs and traps all along the coast there seems to be no definite run of them inshore. On the other hand they are often met far at sea, and it is generally taken for granted that the schools of herring encountered out in the open Gulf in summer belong to this category, for when a mackerel seiner picks up such a school [98] the fish usually are very fat and show no signs of approaching sexual maturity.

Some years these "summer" herring, weighing about 1 pound and very fat (locally they are called "spawn" herring, but this is an error), are taken in the traps at Provincetown for a week or so about mid-April. They are met at about the same time off Gloucester (in 1915 they were reported 8 to 15 miles off Cape Ann on the 17th), and they are said by the fishermen to work eastward thereafter, being found off Seguin in May and June and off Mount Desert in late summer. As a rule few of them are taken inside the islands, but these "fat" herring came right into the harbor of Boothbay about May 14 in 1914. Fishermen universally agree that they follow the coast only as far east as Mount Desert Rock, hence it is probable that they pass the late summer and early autumn offshore in the northeast corner of the Gulf, after which they drop out of sight.

The large mature herring (in the fourth summer and older) live some distance offshore during most of the year and, as European experience suggests, near bottom, coming inshore only to spawn, for they are neither caught along shore nor seen schooling on the surface except for a brief period before, during, and after the spawning season. Since they are to be found throughout the year in the Bay of Fundy, however, it is not probable that they travel far. The date of their appearance on the coast depends not only on the date when spawning commences (p. 96), but to some extent on purely geographical conditions, for they show about the

[98] Many events of this sort have been reported. For example, a large catch of fat summer herring was made on Georges Bank and reported to the Massachusetts Commissioners in the midsummer of 1901.

off-lying islands some time before they make their way up the bays, two or three weeks earlier, for instance, at Grand Manan, Jonesport, and about Mount Desert Island than within Machias Bay. At Isle au Haut, at the eastern entrance of Penobscot Bay, and at Castine, within the Bay, they appear some time after the middle of July, but not until the end of that month or the first of August at Matinicus, while they are not to be expected in the Massachusetts Bay region until the last week in September. By October they are in full force all along the shore of the Gulf from Cape Cod to Grand Manan, and are equally widespread, if less abundant, inshore in November, occasionally being reported in December and even later. It is probable that as the fish spawn out they move out promptly from the spawning grounds into deep water, for but few recently spent fish are taken in the weirs.

Summary.—The young herring 1 and 2 years of age come inshore early in spring and spend the summer and autumn on the New England, New Brunswick, and Nova Scotian coasts; the sexually mature herring come in only to spawn, while the "fat" immature herring as a rule summer in the deeper water outside the outer islands.

A question often asked but which can not yet be answered in a satisfactory way is "just where do the Gulf of Maine herring winter?" In the case of the spring spawners that formerly inhabited the Bay of Fundy the wintering ground apparently lay between Grand Manan and the neighboring mainland of New Brunswick, where a considerable winter fishery was formerly carried on. Probably the autumn spawners, both young and adult, merely descend into deeper water to winter, as is the case in European waters, but how far or how deep the great body of them go is not known. It has been proven, however, that herring of practically all ages remain in the open Bay of Fundy throughout the cold season, and the abundance in the deeper water layers of the northeast corner of the Gulf of pelagic euphausiid shrimps, a favorite herring food, suggests this as a rich winter pasture for them.

Herring on the offshore banks.—Very little is known about the status of the herring on the offshore banks. Occasionally schools (invariably proving to be "fat" if captured) are encountered on Georges Bank and in the deep water to the north of it (p. 101). During the early years of the Georges Bank cod fishery (about the middle of the past century) great schools of herring were seen there and the fishermen made a regular practice of setting herring drift nets for bait, but the facts that the beam trawlers very seldom catch herring there (then only an odd fish) and that the stomachs of cod and haddock caught on the Bank seldom if ever contain herring,[99] is evidence that no great body[1] of the latter seeks the Bank for wintering.

Since sperling are unknown on Georges Bank—a fact commented on by Storer long ago—it seems that herring seldom move so far out to sea until they are 2 years old.

[99] W. F. Clapp found no herring in many cod and haddock stomachs from Georges.

[1] During the beam trawler investigations of 1913 herring were reported for almost every month in the year, never, however, more than a dozen or so fish on any trip, and usually only one or two.

Food.—The herring is a plankton feeder. When first hatched, and before the disappearance of the yolk sac, the larvæ (European) feed on larval gastropods, diatoms, peridinians, and crustacean larvæ, but they soon begin taking copepods, and after they are 12 mm. long depend on them exclusively for a time, particularly on the little *Pseudocalanus elongatus*.[2] As they grow older they feed more and more on larger prey, turning to the larger copepods and amphipods, pelagic shrimps, and decapod crustacean larvæ. Examination of 1,500 stomachs [3] showed that adult herring near Eastport were living solely on copepods and pelagic shrimps, fish less than 4 inches long depending on the former only while the larger herring were eating both. When feeding on copepods herring swim open-mouthed, often with their snouts at the surface, crossing and recrossing in their tracks and evidently straining out the minute crustaceans by means of their branchial sieves, a straining apparatus of coarser mesh than that of the menhaden and consequently capturing larger plankton and letting the microscopic plants pass through.

When feeding on euphausiids, as we ourselves have often seen them engaged and with which the large fish are often gorged, they pursue the individual shrimps, which often leap clear of the water in their efforts to escape. Even in winter when shrimp are rarely seen on the surface Moore found them an important article in the diet of the herring, and it is not unlikely that the local appearances and disappearances of schools of large fish in the open Gulf are connected with the presence or absence of shrimp. In the Gulf of Maine these pelagic shrimp (euphausiids) are taken by herring in preference to any other food, and are voluntarily selected from among the hosts of copepods by such fish as are large enough to devour them. Even when both shrimp and copepods abound, however, a few of the larger fish, as well as the smaller, will usually be found full of copepods, though most of them are packed with shrimp, and in the absence of shrimp (which are seldom abundant west of Mount Desert except during brief periods) copepods are the chief dependence of all our herring, large and small. Such, for instance, is the case at Woods Hole, where copepods had been the chief diet of almost all the herring examined by Doctor Linton during the summer of 1918, and there can be little doubt that they actually select copepods in preference to other small floating organisms, for they are often found packed with them at times and places when the tow nets reveal the presence of a great variety of other animals. In European seas the amphipod genus Euthemisto is also an important food for herring, hence it is to no hesitancy to capture them that the absence of Euthemisto from the herring stomachs examined by Moore and by us is due, but to the comparative scarcity of this large active crustacean in the coastwise waters of the Gulf of Maine.

In default of an abundant supply of Crustacea, and sometimes even when these are plentiful, herring feed on whatever molluscan larvæ, fish eggs, Sagittæ, pteropods, annelids, etc., the water contains, even on objects as small as tintinnids and Halosphæra, but the smaller microscopic plants, either diatom or Peridinian, are never found in the stomachs of herring more than 15 to 20 mm. long, probably

[2] The diet of the young herring in the English Channel has been described by Lebour in a series of papers, especially in Journal, Marine Biological Association of the United Kingdom, Vol. XII, September, 1921, pp. 458–467. Plymouth.

[3] Moore, 1898, p. 402.

because their gill rakers are not fine enough to retain them. Although herring normally are not fish eaters, small launce, silversides, and the young of their own species have been found in them at Woods Hole.

Unfortunately the particular species of copepods on which Gulf of Maine and Woods Hole herring gorge have not been identified, but we might guess that Calanus, with Pseudocalanus, Acartia, and Centropages predominate, while at its times of abundance Temora no doubt looms large in the diet of the herring here as it does in the Irish Sea, and Euchæta offers a rich food supply when the schools seek the deep waters of the basin where these mammoth copepods abound.

Enemies.—The herring is the best of all bait in the Gulf. Naturally, then, it is preyed upon by all kinds of predaceous fish, especially by cod, pollock, haddock, silver hake, mackerel, salmon, dogfish and other sharks. Silver hake in particular often drive schools of herring right up on our beaches, where pursued and pursuers alike strand on the shoaling bottom. The finback whales also devour them in great quantities, and the common squid (Ommastrephes) destroys multitudes of the young sardines.

Destruction by natural causes.—The herring is a very "tender" fish, proverbially prone to wholesale destruction by stranding on beaches during storms and by pollution of the water. Many instances of this kind have been reported. Allen,[4] for example, saw young herring in windrows for miles on the strand at Rye Beach in August, 1911. A slaughter of herring, more instructive because the exact course of events was followed, occurred at Cohasset, on the south shore of Massachusetts Bay, in October, 1920. On the 5th of that month a large school of sperling, 4 to 5 inches in length, ran up the harbor (which is nearly landlocked), probably driven in by silver hake (at least so local fishermen said), were trapped there by the falling tide, and stranded on the mud. So numerous were they that the flats were entirely covered with them and it was estimated that 20,000 barrels of fish perished. During the next few days the fish, alternately covered and uncovered by the tide, decayed and in spite of tidal circulation so fouled the water that lobsters died in the floating cars. On the 10th there was a second but smaller run of herring, and on the 15th a run as large as the first occurred, the newcomers dying soon after they entered the harbor. Altogether, it was estimated that 50,000 barrels of fish perished, of which over 90 per cent were sperling, 5 to 10 per cent were large adults, and a few were small mackerel and silver hake, besides large numbers of smelt. By the last half of October, when I saw them, the flats were silvery with herring scales at low tide, and the residents about the harbor found the stench almost unbearable. During the winter months the fish entirely decomposed and the water purified itself. In north European waters vast quantities of herring spawn are likewise cast up on the beaches every year to perish.

Annual fluctuation in the supply of herring.—Many times during the past 75 years the complaint has been made that the herring of the Gulf of Maine are diminishing in number, but Moore (1898), who sifted many sources of information, concluded (we believe rightly) that there had been no general decrease in the abundance

[4] Memoirs, Boston Society of Natural History, vol. 8, No. 2, 1916, p. 202.

of young herring at the mouth of the Bay of Fundy up to that time, though the numbers of herring visiting any given locality on our coast and the duration of their stay vary widely from year to year. As far back as the period from 1837 to 1857 Massachusetts Bay saw a marked diminution of the local supply of herring followed shortly by its reestablishment in full strength, and any particular locality—for instance the Eastport region or Wood Island—would no doubt show similar ups and downs from year to year or over periods of years. Local spawning grounds, too, may be abandoned for a term of years—a very common occurrence.[5] The fact that the catch varies widely from year to year is not governed altogether by the abundance of the fish themselves, for sundry economic factors enter in, and except for the disappearance of the spring spawners from the Bay of Fundy no general alteration, one way or another, far-reaching enough to have impressed itself unmistakably on those chiefly concerned, has taken place in the herring supply of the Gulf in recent years. In short, Capt. John Smith's (1616, p. 188) account of the herring applies as well to-day: "The savages compare the store in the sea with the hairs of their heads, and surely there are an incredible abundance upon this coast."

In the year 1919 more than 110,000,000 pounds of herring were caught in the Gulf, about 3,400,000 pounds being taken on the Nova Scotia shore, 10,415,000 on the New Brunswick shore, 86,700,000 off the Maine coast, and 10,800,000 off Massachusetts. Since at least 80 per cent of the total catch consisted of "sardines," that is, of fish of only a few ounces weight, the toll taken can not have been less than half a billion fish. Unfortunately, however, present plenty is no guaranty of permanent abundance, for the history of the herring fisheries on the other side of the Atlantic, where the record runs back for centuries, has been a succession of periods of plenty and of scarcity since the earliest times.

40. **Hickory shad** (*Pomolobus mediocris* Mitchill)

FALL HERRING; SHAD HERRING

Jordan and Evermann, 1896–1900, p. 425.

Description.—The hickory shad is distinguishable from the common sea herring by the absence of vomerine teeth, its very deep belly, upper jaw notched at the tip, and the fact that its outline tapers toward both snout and tail in side view (fig. 43). A hickory shad 13½ inches long is about 4 inches deep, while a herring of that length is only 3 inches deep. Furthermore, in the hickory shad the lower jaw projects much more than in the herring and the dorsal fin originates nearer the snout than the tail, whereas in the herring it is about midway of the length of the body though the difference in this respect is not great. One is more likely to confuse this fish with the alewives, which resemble it in the great depth of the body. It can be distinguished from the blueback by the color of the lining of the belly, which

[5] Moore, 1898, p. 430.

is pale gray instead of black, and there is also a slight difference in outline, the hickory shad being the deeper of the two, with a more tapering head, its lower jaw projecting relatively farther. The hickory shad is distinguishable from the common alewife (in which the lining of the belly is likewise gray) by tapering forward from its greatest depth, whereas the latter is heavy bodied forward of the dorsal and ventral fins, as well as by its sharp head, longer jaw, smaller dorsal fin, only about one-half as many gill rakers (about 30 on the first gill arch), and, under favorable circumstances, by its color, being faintly marked on the sides with longitudinal stripes. The projecting lower jaw of the hickory shad marks it off from the shad.

Size.—This, next to the shad, is the largest of our anadromous herrings, growing to a length of 2 feet and a weight of 2½ pounds.

General range. Atlantic coast of North America from the Bay of Fundy to Florida, running up into fresh water to spawn.

Occurrence in the Gulf of Maine.—The hickory shad is a more southern fish than either of the alewives, the Gulf of Maine marking the extreme northern limit to its range. So far as known, it does not breed in any of the rivers north of Cape

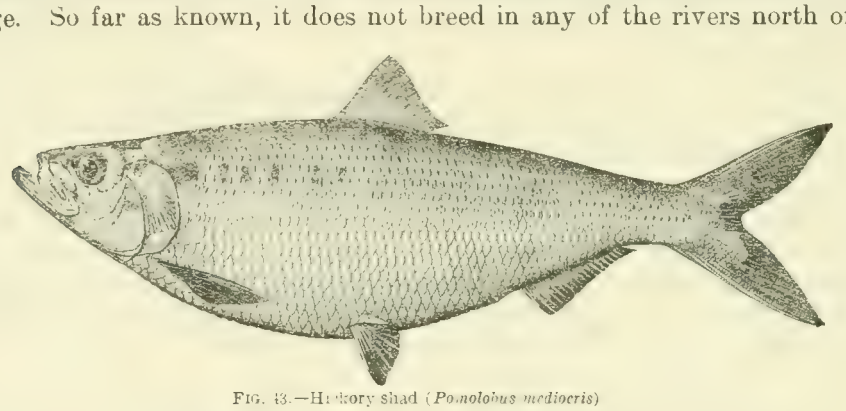

FIG. 13.—Hickory shad (*Pomolobus mediocris*)

Cod and is so rare a fish within its limits that although recorded from the mouth of the Bay of Fundy (Huntsman doubts this record), from Casco Bay, off Portland, at the mouths of various rivers in Maine where odd fish are taken from time to time by gill-netters, in Boston Harbor, at Provincetown, and at North Truro in Massachusetts, we have not seen a single specimen among the thousands of herring and alewives that have passed through our hands. West of Cape Cod, however, it is much more plentiful, being common from spring throughout summer and early autumn at Woods Hole, where as many as 3,500 have been taken at a single lift of one trap. In 1919 the Massachusetts catch of hickory shad, practically all from the south coast, amounted to 12,800 pounds.

Habits.—Nothing is known of the habits of the hickory shad in the sea to differentiate it from its close relatives, the alewives, except that it is more of a fish eater, as might be expected from its large mouth and strong jaws. Launce, anchovies, cunners, herring, scup, silversides, and other small fish, squid, fish eggs, and even small crabs, as well as sundry pelagic Crustacea, have been found in the stomachs of hickory shad at Woods Hole by Vinal Edwards.

41. Alewife (*Pomolobus pseudoharengus* Wilson)

GASPEREAU; SAWBELLY; KYAK; BRANCH HERRING; FRESH-WATER HERRING; GRAYBACK

Jordan and Evermann, 1896–1900, p. 426.

Description.—The lack of vomerine teeth distinguishes the alewife, with its brethren, the hickory shad (p. 105) and blueback (p. 110), from the sea herring, but even without the slight examination of the mouth which determination of this point entails, it is distinguishable at a glance from it by the greater depth of its body, which is three and one-third times as long as deep—an alewife of 13½ inches being about 4 inches deep while a herring has a depth of only 3 inches. Furthermore, the alewife is much more heavily built forward than is the herring, and the serrations of the midline of its belly are much stronger and sharper—hence the local name "sawbelly"—so much so that a practiced hand can separate herring from alewives in the dark. The most useful distinction between the alewife and the blueback is the fact

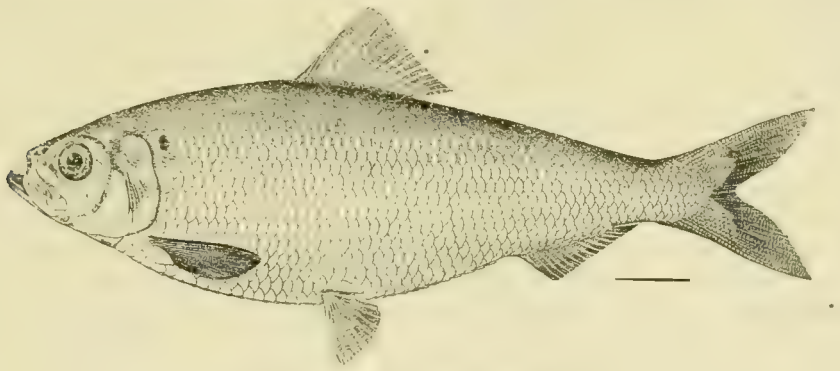

FIG. 44.—Alewife (*Pomolobus pseudoharengus*)

that the lining of the belly is pale in the former and black in the latter. Alewives are distinguished from young shad by the projection of the tip of the lower jaw beyond the upper when the mouth is closed, and by the fact that the outline of the edge of the lower jaw is deeply concave in the alewife and nearly straight in the shad.

Color.—The alewife, like the herring, is dark green blue above, darkest on the back, paler and silvery on sides and belly. Usually there is a dusky spot on either side just behind the margin of the gill cover (lacking in the herring) and in large fish the upper side may be faintly striped with dark longitudinal lines. In life the sides are iridescent with lines of green and violet.

Size.—The alewife grows to a length of about 1 foot, adults averaging about 10 inches long and slightly more than half a pound in weight; 16,400,000 taken in New England in 1898 weighing about 8,800,000 pounds.

General range.—Nova Scotia and the Gulf of St. Lawrence south to the Carolinas, running up into fresh water to spawn.

Occurrence in the Gulf of Maine.—When the white man crossed the Atlantic probably there was no stream from Cape Sable to Cape Cod but saw its annual run

of alewives unless they were barred by impassable falls near the mouth. In the words of an eyewitness, "experience hath taught them at New Plymouth that in April there is a fish much like a herring that comes up into the small brooks to spawn, and when the water is not knee deep they will presse up through your hands, yea, thow you beat at them with cudgels, and in such abundance as is incredible." [6]

During the past two centuries, however, its numbers have declined and its range has been restricted, both by actual extirpation from certain streams by overfishing, by the pollution of the river waters by manufacturing wastes, and by the erection of dams that it can not pass. However, the alewife is still a familiar fish all along our coast,[7] and yields an abundant catch in many of our streams. Alewives are taken commonly about Yarmouth, Nova Scotia, and they are locally abundant in the Bay of Fundy, e. g., in Minas Channel in the Annapolis Basin as well as at other localities farther up the bay, with large runs in the St. John River; and passing along the coast of Maine we find them entering both the large river systems and their tributaries and innumerable small streams, the one requirement being that these shall lead to ponds. At Boothbay Harbor, for instance, a considerable stock of alewives annually runs up to spawn in Campbell's Pond, a small body of water dammed off from the harbor and reached by a short fishway only 15 feet long. Perhaps this is our shortest alewife stream.

Alewives also breed in many ponds lying back of barrier beaches, which they enter through artificial cuts opened on purpose. To show how catholic the alewife is in its choice of rivers we may point out that in 1896, when the fishery was the subject of inquiry by the Bureau of Fisheries,[8] catches large enough to be worth special notice were reported from the mouths of the St. Croix, Dennys, Machias, Medomak, Penobscot, St. George, Pemaquid, Damariscotta, and Kennebec Rivers, from Casco Bay, and from sundry other shore localities in Maine, from the Piscataqua River system in New Hampshire, the mouth of the Merrimac, and from Cape Cod Bay in Massachusetts north of Cape Cod, but few alewives now ascend the Merrimac, so polluted is it and obstructed by dams, though fishways recently constructed now allow some to ascend beyond Lowell, Mass. In 1921 Belding found them still running in only about 12 streams on the Gulf of Maine coast of Massachusetts (and very few in these) out of 27 streams that formerly supported considerable alewife fisheries. The fact that in 1896, 5,832,900 were caught along the coast and river mouths of Maine, 526,500 in New Hampshire, 2,677,972 as the combined catch of the Merrimac River and of Cape Cod Bay, suggesting a total of not less than 3,000,000 for Massachusetts north of Cape Cod,[9] i. e., at least 9,300,000 (in actuality probably considerably more than 10,000,000) alewives of marketable size from the western and northern shores of the Gulf, will illustrate the numerical strength of this fish. This does not include the yield of the Bay of Fundy

[6] Capt. Charles Whitborne, in "The True Travels of Capt. John Smith," etc., 1616, vol. 2, p. 250.

[7] Belding (1921) has given a very instructive report on the alewife in Massachusetts.

[8] Smith, H. M. Report, U. S. Commissioner of Fish and Fisheries, 1898 (1899), pp. 31–43.

[9] The total alewife catch for Massachusetts was about 10,000,000 fish, but most of these were from the streams emptying on the other side of Cape Cod.

nor of the west coast of Nova Scotia, for which no precise statistics are available. Large though these figures are, however, and numerous though the alewives seem when crowding into streams, they make but a sparse population as compared to the sea herring when spread over the Gulf. For example, in the year 1920 seiners and drift-netters fishing offshore brought into Boston, Gloucester, and Portland only 31,650 pounds of alewives and bluebacks combined, as contrasted with 4,000,000 pounds of herring.[10]

Habits.—The first alewives appear early in April in the few streams tributary to Massachusetts Bay that they still frequent, but they are seldom seen in Maine rivers or in the St. John until late April or early May, a difference in date probably depending on the temperature of the water. Thereafter successive runs follow (the last half of May seeing the heaviest) until well into June. In 1915, for example, alewives appeared in Campbell's Creek at Boothbay Harbor on April 20, and were still running as late as May 20, by which date spent fish on their return trip to salt water were passing those coming in. During the early runs sometimes one sex predominates, sometimes the other, but as a rule the late runs consist chiefly of males and these greatly outnumber the females on the spawning grounds.

The alewife spawns in ponds, never in running streams, each female depositing from 60,000 to 100,000 eggs, according to her size.[11] Spawning lasts only a few days for each group of fish, taking place at a temperature of 55° to 60°, the spent fish running downstream again soon after spawning, some commencing this return journey as early as May. Incubation occupies 6 days at a temperature of 60°. The young alewives,[12] which are about 5 mm. long when hatched, growing to 15 mm. when a month old, soon begin to work their way downstream, successive companies of fry moving out of the pond and down with the current throughout the summer. They have been seen descending as early as June 15 and by autumn, when 2 to 4 inches long, the young alewives have all found their way down to salt water. Thenceforth the alewife lives in the sea until sexually mature and very little is known about its habits or migrations. As every fisherman knows, it is as gregarious as the herring, fish of a size congregating in schools of thousands of individuals (we find record of 40,000 fish caught in one seine haul in Boston Harbor) and apparently any school holds together during most of its sojourn in salt water. At times, however, alewives are caught mixed with menhaden, herring, or bluebacks. Although alewives, immature and adult, are often picked up in abundance in weirs here and there along the coast, it seems that most of them, like the "fat" herring (p. 101), keep outside the islands, and the fact that odd alewives were reported from Georges Bank in March, June, and August, 1913 (39, indeed, were taken on one trip), and a few caught in the trawls in the South Channel in November, proves that they may wander far offshore. The alewife, like the herring, drops out of sight in winter, but probably it simply moves offshore then, living near

[10] This takes no account of the tremendous shore catch of herring mentioned on p. 105.

[11] The average number of eggs in 644 females taken in the Potomac was 102,800. (Smith, H. M. North Carolina Geological and Economic Survey, Vol. II, 1907, pp. 1–449. Raleigh.)

[12] The development of the eggs, larval stages, and young fry are described by Ryder (Report, U. S. Commissioner of Fish and Fisheries, 1885 (1887), p. 505) and by Prince (1907, p. 95).

the bottom like the latter, for Huntsman (1922a, p. 10) reports its young at Campobello Island, Bay of Fundy, in December and March.

The rate of growth of the alewife during its sojourn in the sea has not been studied, but experiments in stocking ponds with alewives long ago led to the conclusion that they attain sexual maturity at 3 or 4 years of age. This has been confirmed on many occasions in recent years, for it has proved easy to restock suitable streams with alewives by planting adult spawners at the proper season in the ponds which they drain, as has been done in many localities in Massachusetts. In the third year after the "plant," and not until then, the progeny appear in the stream. The success of such restocking operations, moreover, has demonstrated that the "parent stream" theory—that is, that alewives, like shad, return to spawn in the stream in which they were hatched—is correct. We have no record in historic times of their having spontaneously adopted a stream previously barren of them.

Alewives return to the sea immediately after spawning (the old belief that they spawn but once and then die has no foundation), the spent fish on their return journey to salt water being familiar sights in every alewife stream. After spawning they are thin, but we have seen spent alewives that had already put on considerable fat taken from a trap at Provincetown as early in the season as July 16 in 1915.

Food.—The alewife, like the herring, is chiefly a plankton feeder, copepods, amphipods, shrimps, and appendicularians being the chief diet of specimens examined by Vinal Edwards and Linton at Woods Hole. However, they also take small fish, such as herring, eels, launce, cunners, and their own species, as well as fish eggs. Unlike the herring, alewives often contain diatoms even when adult. Alewives fast when they are running upstream to spawn, but when the spent fish reach brackish water on their return they feed ravenously on the shrimp that abound in the tidal estuaries and which they can be seen pursuing.

Commercial importance.—Alewives are excellent food fish, preferred by many to the sea herring, and a favorite bait for cod, haddock, and pollock. They are of considerable commercial importance among the minor fisheries.[13]

42. **Blueback** (*Pomolobus æstivalis* Mitchill)

ALEWIFE; GLUT HERRING; SUMMER HERRING; BLACKBELLY; KYACK

Jordan and Evermann, 1896–1900, p. 426.

Description.—Bluebacks and alewives are often confused; even experienced fishermen who recognize the existence of the two separate fish can not always tell them apart, so closely do they resemble one another in general appearance. There is one infallible mark, however, that distinguishes the "blackbelly" not only from the alewife but from the hickory shad and herring as well, and that is that the lining of its belly is black, or at least black-spotted, instead of smoky gray as in its relatives. Apart from this we need state only that it is a slightly more slender fish than the

[13] For a brief period during the war alewife scales commanded a high price for use in the manufacture of artificial pearls.

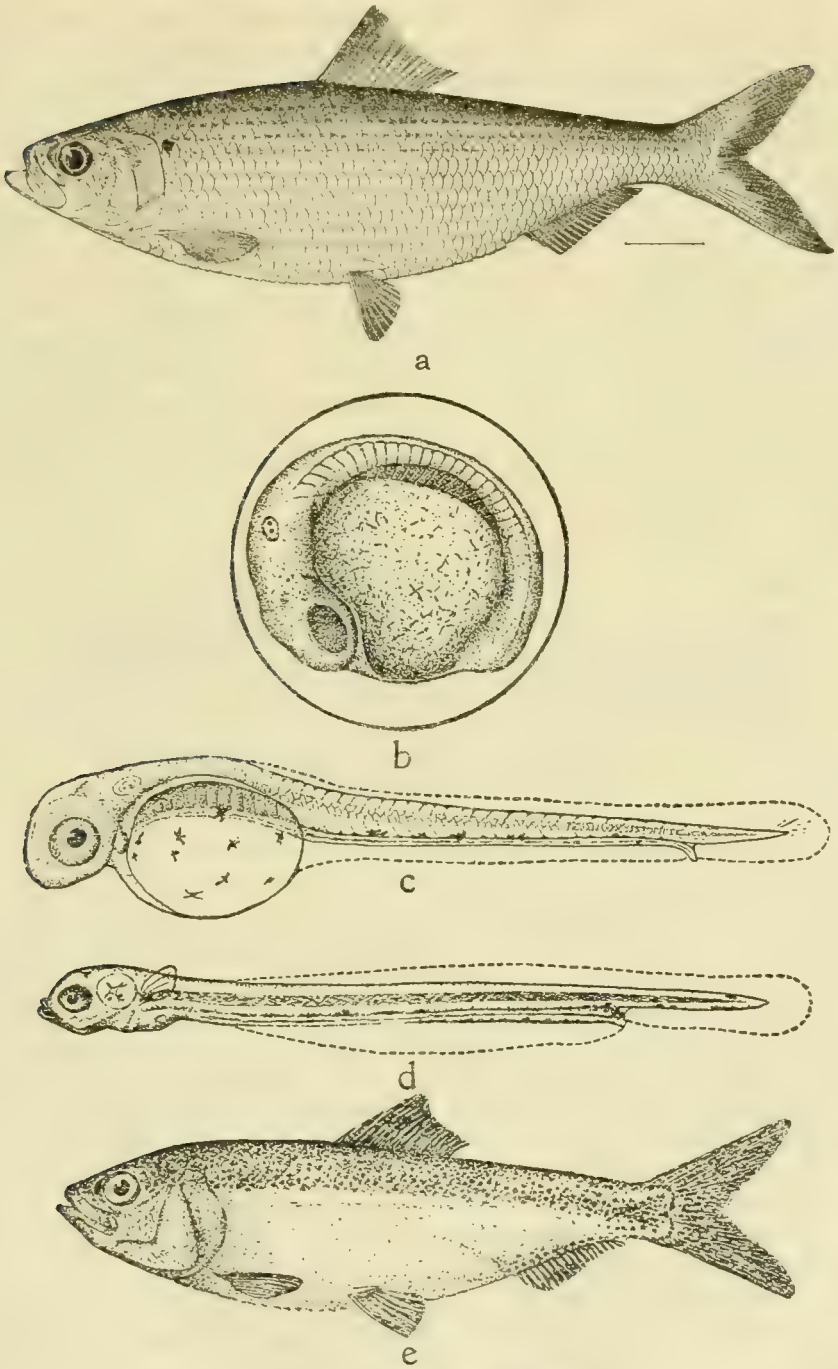

FIG. 45.—Blueback (*Pomolobus æstivalis*)

a, Adult. *b*, Egg. *c*, Larva, newly hatched, 3.5 millimeters. *d*, Larva, 4 days old, 5.2 millimeters. *e*, Fry, 30 millimeters

alewife (its body three and one-half times as long as deep), though differing so little in this respect that the two probably intergrade; that the fins are lower (here, again, the difference is so slight as to be hardly dependable); its eyes are smaller; and its back is rather darker blue; but, we repeat, to make certain which fish is in hand open it, glance at the belly lining, and no doubt will remain.

Size.—The blueback is of about the same size as the alewife. It grows to a length of about a foot and averages about a half pound in weight when mature.

Color.—Dark blue above, the sides and belly silvery, with coppery reflections at least in some waters.

General range.—This is a more southern fish than the alewife, occurring off the Atlantic coast of North America from the Bay of Fundy and Nova Scotia to Florida. It is more numerous south than north of Cape Cod, and like the alewife spends the greater part of the year in salt water but runs up into brackish and fresh water to spawn.

Occurrence in the Gulf of Maine.—Although Massachusetts fishermen have recognized the existence of two distinct species of alewives at least since 1816, it is difficult to arrive at a just idea of the abundance and migrations of this fish in the Gulf, because when "bluebacks" are reported they sometimes turn out to be alewives, while we have heard the latest run of alewives called bluebacks even in streams where the true blueback also occurs. It is certain, however, that schools of the latter are to be expected anywhere between Cape Sable and Cape Cod, for we have seen them freshly caught at Yarmouth on the west coast of Nova Scotia; they are not uncommon in the Bay of Fundy, Huntsman having had specimens from St. John Harbor and Shubenacadie River; they are definitely reported from the St. Croix River, from Eastport, Bucksport, Dennys River, Casco Bay, Small Point, Freeport, and sundry other localities along the coast of Maine, and are taken generally around the shores of Massachusetts Bay, including Cape Cod. Large numbers of bluebacks are sent to market, schools often being seined off the Maine coast outside the islands during summer and early autumn. These are mostly the 2-year-old fish, not yet sexually mature, judging from the fact that they are usually reported as very fat. Weirs also make large catches of bluebacks from time to time, and we have seen thousands of them taken from a trap near Gloucester in June. How far offshore the bluebacks may wander is unknown. A few fish were reported under this name from Georges Bank during the investigation of 1913, but whether they were actually bluebacks or alewives is doubtful. It is sufficiently established that the blueback appears in our streams two weeks to a month later than the alewife, and that in streams frequented by both the later runs are bluebacks and the earlier ones are alewives. In the Gulf of Maine, at least, it is apparently confined as a spawner to brackish ponds connected with the ocean and to the larger rivers,[14] nor does it run far above tide water.

Habits.—The spawning habits of the blueback do not differ in any important particular from those of the alewife, except that it does not spawn until the water

[14] Along the south shore of Massachusetts, for instance about the head of Buzzards Bay, bluebacks, like alewives, run up small streams.

is much warmer—70° to 75° instead of 55° to 60°.[15] No exact information as to the time of spawning in northern New England rivers is available. About Woods Hole this takes place in early summer in small ponds with an outlet to salt water, most of the females being spent, a few females and many males ripe, and others of both sexes still unripe in July. The eggs are about 1 mm. in diameter, sink like those of the alewife, and are adhesive. Incubation occupies only about 50 hours at a temperature of 72°, the newly hatched larvæ averaging 3.5 mm. in length but growing within 24 hours after hatching to 4 mm., with the greater part of the yolk sac already absorbed. Within a month they are 30 to 50 mm. long, and already show most of the diagnostic characters of the adult. Evidently the young soon find their way down to the sea, for bluebacks of 50 mm. have been seined in abundance in Rhode Island waters late in July. Nothing whatever is known of their rate of growth there. The spent fish, like alewives, return to sea shortly after spawning. Probably these are the bluebacks taken at Woods Hole and north of Cape Cod in September and October. The winter home of our bluebacks is

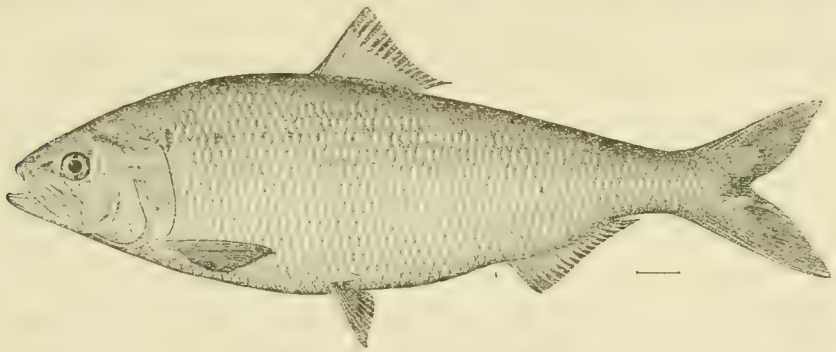

FIG. 46.—Adult shad (*Alosa sapidissima*)

unknown; probably, like their relative the sea herring, they move out from land and pass the cold season near the bottom.

We need only note further that the blueback is as gregarious as the herring or alewife; that it is equally a plankton feeder, subsisting chiefly on copepods and pelagic shrimp, as well as on young launce and, no doubt, on other small fish fry. In commercial use no distinction is made on our coast between the blueback and the more abundant alewife—it is equally useful for bait and human food.

43. **Shad** (*Alosa sapidissima* Wilson)

Jordan and Evermann, 1896–1900, p. 427.

Description.—The shad resembles the alewife in the fact that its body is much deeper than thick and that its belly is sharp edged with bony serrations. In all respects it is a typical herring, with soft rayed dorsal and anal fins of moderate size, the former situated above the ventrals and well forward of the middle of the body.

[15] The early development and larval stages of the blueback are described by Kuntz and Radcliffe (1918, pp. 87–134).

It has a deeply-forked tail and large and very easily loosened scales. Unlike the sea herring, however, the shad has no vomerine teeth—adults, indeed, have no teeth at all, although young shad have small ones in the jaws which may persist until the fish is a foot or more long. It is easily recognized, being the deepest bodied of our herrings, a third as deep as long, and further marked among its relatives by the fact that the upper jaw is deeply notched at the tip with the end of the lower jaw fitting into the upper when the mouth is closed. The mouth, too, opens back farther than in the alewives, and the edge of the lower jaw is straight, not concave, as in the latter. The under jaw does not project noticeably beyond the upper, as in the alewives and especially in the hickory shad. Furthermore, the lining of the shad's belly is white—neither gray as in the herring and alewife nor black as in the blueback.

Size.—The shad is the largest of herrings that regularly visit our Gulf, growing to a length of 2½ feet. Adult males run in weight from 1½ to 6 pounds; females from 3½ to 8 pounds. Shad are occasionally reported up to 12 pounds, and the older writers mention them as heavy as 14 pounds, but none so large has been credibly reported in the Gulf of late years.

Color.—Dark bluish or greenish above, white and silvery on sides and belly,

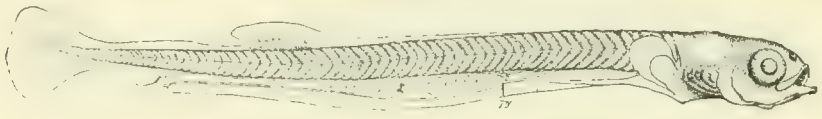

FIG. 47.—Larva of the shad (*Alosa sapidissima*), 17 days old

with a dusky spot close behind the rear edge of the gill cover, and frequently with several indistinct dusky spots in one or two longitudinal rows behind it.

General range.—Atlantic coast of North America from the Gulf of St. Lawrence to Florida, and represented by a close ally or variety in the Gulf of Mexico. It also has been successfully introduced on the Pacific coast of the United States. It runs up rivers into fresh water to spawn.

Occurrence in the Gulf of Maine.—When the first settlers arrived in New England, they found seemingly inexhaustible multitudes of shad annually running up all the larger rivers and many of the smaller streams from Nova Scotia to Florida, with the tributaries of the Gulf of Maine hardly less productive than the Hudson or Delaware; but as one stream after another was rendered impassable, or at least very difficult for the fish to ascend, by the construction of dams near the mouths, the local stock of shad has diminished until now the Gulf of Maine stock is but a shadow of its former abundance, a fact more than one writer has taken a melancholy pleasure in lamenting. Since it is the present status of the shad with which we are now concerned, the following table of the shrinking catch in the Merrimac will be a sufficient illustration of this depletion.[16]

[16] From Stevensen (1899).

Year	Number of shad caught, reported, or estimated	Year	Number of shad caught, reported, or estimated
1789	830,000	1888	None.
1805	540,000	1889	18
1835	365,000	1890–1892	None.
1865	50,000	1893	2,020
1871–1873 (average)	1,942	1894	2,750
1880	2,139	1895	94
1885	130	1896	7

The only Gulf of Maine rivers to which shad resort regularly at the present time are the Annapolis, Petit Codiac, Shubenacadie, and St. John, tributary to the Bay of Fundy, and the St. Croix,[17] Pleasant, Harrington, Penobscot, and Kennebec Rivers [18] in Maine. In the year 1896, 290,122 shad were reported as caught in the Kennebec system; 900 in the Pleasant; 300 in the Harrington River; only 114 in the Penobscot and 12 in the St. Croix; 100 in the Piscataqua; and 7 in the Merrimac. Since then the stock has fallen even lower, for in 1919 the catch in Washington County, Me., which includes the St. Croix, Pleasant, and Harrington Rivers, was only 400 pounds, say 100 fish, assuming them to average 4 pounds, with only 131 pounds (30 to 40 fish) taken in the Penobscot River, 3,121 pounds (700 to 800 fish) in Penobscot Bay, and 178,434 pounds (about 45,000 fish) from the Kennebec, its tributary estuaries and neighboring shore line (Sagadahoc and Lincoln Counties), that is, only about one-sixth as many as in 1896. In 1919 the total inshore and offshore catch for American fishermen in the Gulf of Maine north of Cape Cod was about 460,000 pounds (about 115,000 fish). No statistics are available for the few shad caught in the Bay of Fundy that year, but in 1916–17 the catch of shad in the Bay of Fundy was about 365,000 pounds, with about 9,000 pounds more along the west coast of Nova Scotia.

The shad in salt water.—The life of the shad in salt water has long been considered something of a mystery, but evidence gradually accumulates to the effect that its movements there are analogous to those of the herring, and that it does not perform the extensive north and south migrations with which it was formerly credited.

Commencing with the spent shad on their return to the sea [19] we find the New Brunswick fish (no doubt the Nova Scotian, also) making their way to the head of the Bay of Fundy on their return to the sea to fatten until they become the "fall shad" that are locally considered the choicest of fish. Large spent shad—presumably fish that have spawned in the Kennebec—are regularly caught in September and October about Mount Desert, where they have been the object of

[17] The St. Croix formerly supported a large stock of shad. For 8 or 9 years prior to 1915 none came, but shad were again fairly plentiful in 1915 to 1916, according to investigations made by H. F. Taylor of the U. S. Bureau of Fisheries.

[18] Shad have been entirely extirpated from the Saco, where they were formerly plentiful.

[19] The following notes are based largely on reports by reliable fishermen and on our own observations, which we have gathered from catches during our several years' work on the New England coast.

a considerable frozen-fish industry of late,[20] as well as near the Isles of Shoals and off York Beach in August, while it has long been known that shad are present 40 to 50 miles at sea off the Maine coast throughout the autumn. A southward movement of these Bay of Fundy and Kennebec spawners is the most reasonable explanation for the yearly presence off Cape Ann, from mid-October until into December,[21] of large shad running from 1½ up to 10 pounds (averaging about 5 pounds), that is, fish that have spawned during the preceding summer. As a rule they are not abundant; sometimes, however, the pollock-netters make large hauls of them, as in the autumn of 1915, when 135,000 pounds of these large fish were caught near Gloucester. Sometime in December the large shad vanish, where they winter still being a matter for conjecture. Probably they sink and move out beyond the limits of extreme winter chilling, which may lead them to the central basin of the Gulf, a suggestion yet to be confirmed by actual captures of shad in winter but in line with the prevalent view that the shad of the middle and south Atlantic coasts of the United States move offshore to pass the cold season on the bottom. The young shad of the year, produced in southern rivers, are believed to winter near the mouths of their parent streams and this probably applies to the Gulf of Maine also.

The mature shad with ripening sexual organs reappear off the western shores of the Gulf of Maine in April and May, when a few are picked up by haddock-netters between Cape Ann and Portland; most often about Boon Island and the Isles of Shoals.[22] So few shad now frequent the Merrimac that it is probable these "spring shad" are bound north to the Kennebec River or Bay of Fundy. Except for odd belated individuals the mature shad are all in the rivers or at least close to their mouths by the 10th or 15th of June, not to reappear in the sea until July or August (p. 116).

Schools of small immature shad from a foot long and half a pound in weight up to 2 or 2½ pounds, not yet of breeding age, that is, corresponding to the "fat" herring 2 or 3 years old, are reported every year at Provincetown for a short period in June, are sometimes taken in the weirs at Beverly and Manchester in Massachusetts Bay in June,[23] and are met with more or less commonly all summer off Cape Ann and thence eastward, which corroborates the general belief of local fishermen that they move north and east toward the Bay of Fundy as the summer advances just as the "fat" herring do (p. 101). However, instead of keeping offshore these immature shad (which, like herring of corresponding age, are very fat) congregate in the bays of the Maine coast, even running up into brackish estuaries though never into fresh water. In Casco Bay, for example, where they have long been fished for, 64,490 pounds of shad (probably "fat" fish) were caught in 1896, though by 1919 the local catch had dwindled to only about 12,000 pounds (not over

[20] About 250,000 pounds have been brought into the local freezers yearly from 1913 to 1915.

[21] It has also been suggested that these fish are migrants from the south, visiting the rich plankton pastures of the Gulf for food, an interesting possibility that the evidence yet at hand can neither prove nor disprove.

[22] A series of shad from that region examined by Welsh at various dates (April 25 to May 17, 1913) averaged precisely 5 pounds, both sexes represented, and all with well-developed sexual organs.

[23] Numbers of shad about 14 inches in length were caught in the traps at Magnolia and Beverly from June 20 to July 6, 1921.

5,000 fish, assuming an average of 2½ pounds). They have also been reported in abundance near Cape Ann, off the Isles of Shoals, near Boothbay Harbor, and at Herring Cove near Eastport, Me.

Summary.—The evidence at hand suggests that shad, like herring, spend the first winter near the mouth of the river in which they are hatched; that for two or three years, as immatures, they roam our coast in summer, wintering somewhere offshore; and that finally, as mature breeding fish, they come inshore in spring, run up rivers from April to June to breed, return promptly thereafter to the sea to pass the late summer and autumn, fattening near the surface not far from land, and, like herring, they winter offshore in deep water.

Food.—The shad, like other herrings, is primarily a plankton feeder. We have found shad taken in the Gulf of Maine in summer packed full of copepods (chiefly Calanus), and the stomach contents of fish from the Nova Scotian coast of the Bay of Fundy examined by Willey (1923, p. 11) consisted chiefly of the copepod genera Acartia and Temora with other smaller ones, Mysid shrimps, and the larval stages of barnacles. Shad are also known to feed as greedily on the pelagic euphausiid shrimps as herring do, on fish eggs, and even on bottom-dwelling amphipods, showing that at times they forage near the ground. They are not known to eat fish.

Breeding habits.[24]—It is now sufficiently established that on their spawning migration shad return year after year to the same general region, sound, or estuary; and in the Gulf of Maine, where so few rivers can now serve as spawning grounds, this necessarily means to the same stream, the date when the sexually mature shad enter fresh water being governed by the temperature of the streams—that is, when the river water has warmed to 50° to 55°. Consequently the shad "run" correspondingly later in the year passing from south to north along the coast. Thus the run commences in Georgia in January; in March in the waters tributary to Pamlico and Albemarle Sounds; in April in the Potomac; and in May and June in northern streams generally from the Delaware to Canada. In the Kennebec, according to Atkins (1887), the first shad appear late in April, with the main run in May and June; the first ripe females are caught the last week in May and they begin to spawn about June 1, most of them doing so during that month, a few in July, and possibly an occasional fish as late as August. Probably these dates applied equally to the Merrimac in the good old days when shad were plentiful there, but the season begins somewhat later in the St. John, as might be expected, with the fish running from mid-May until the end of June.

The fish select sandy or pebbly shallows for spawning ground. On the average, females produce about 30,000 eggs, though in the case of very large fish as many as 156,000 have been estimated. After spawning the spent and very emaciated fish at once begin their return journey to the sea. In the Kennebec they are first seen on their way down about June 20 and constantly thereafter throughout July; in the St. John spent fish are running down in July and August. According to

[24] Accounts of the breeding habits of the shad have been given by Ryder, Report U. S. Commissioner of Fish and Fisheries, 1885 (1887); by Prince (1907); and in the Manual of Fish Culture, 1900.

Atkins they begin feeding before reaching salt water and recover a good deal of fat before moving out to sea.

The eggs are transparent, pale pink or amber, and being semibuoyant and not sticky like those of other river herrings they roll about on the bottom with the current. The period of incubation is from 5 to 10 days in the temperatures prevailing in June in the Kennebec and St. John Rivers, having been found by experiment to be as follows:

Water temperature	Period of incubation
74° F. (23.3° C.)	70 hours, or about 3 days.
64° F. (17.8° C.)	109 hours, or about 4½ days.
57° F. (13.9° C.)	148 hours, or about 6 days.
54° F. (12.2° C.)	408 hours, or about 17 days.

The larvæ are about 9.5 mm. long at the time of hatching, growing to 15.5 mm. by the ninth day with disappearance of the yolk sac. At 21 to 28 days the fins are fully developed and the fry have attained a length of about 20 mm. Shad larvæ much resemble herring, being extremely slender with the vent almost as far back as the base of the tail.

The young shad remain in the rivers until fall when, at a length of 1½ to 4½ inches and resembling their parents in appearance, they move down to salt water. The length attained by the shad during its first autumn depends on the date of hatching. In the rivers of Maine the fry may be as long as 5 to 7 inches by the first week in November; even larger (6 to 8 inches) in New York streams.

Nothing definite is known of the rate of growth of the shad after it leaves its parent river; presumably, however, it grows little during the first winter but is about a foot long by the second autumn. It is supposed to mature at about the same age as the alewife—3 or 4 years.

44. **Menhaden** (*Brevoortia tyrannus* Latrobe)

Pogy

Jordan and Evermann, 1896–1900, p. 433.

Description.—This fish is universally called "pogy" in the Gulf of Maine but no less than 30 common names are in use south of Cape Cod. Like all our other herrings it is flattened laterally, has a sharp-edged belly, and is as deep proportionally as the shad (body three times as deep as long), though when the fish are fat the general form is altered. The very large scaleless head, which occupies nearly one-third of the total length of the body, gives the menhaden an appearance so distinctive that it is not apt to be mistaken for any other Gulf of Maine fish. It is likewise distinguishable from all its local relatives by the fact that the rear margins of the scales are vertical—not rounded as in the more typical herrings—and edged with long comblike teeth instead of being smooth. The dorsal fin, furthermore, originates slightly behind the ventrals and is thus posterior to the latter for the whole length, whereas in herring, alewives, and shad it stands directly over the ventrals. We need only point out further that the pogy is toothless, its

tail deeply forked, its ventral fins very small, its dorsal and anal of moderate size, its mouth large and gaping back as far as the hind margin of the eye, and that the tip of its lower jaw projects beyond the upper.

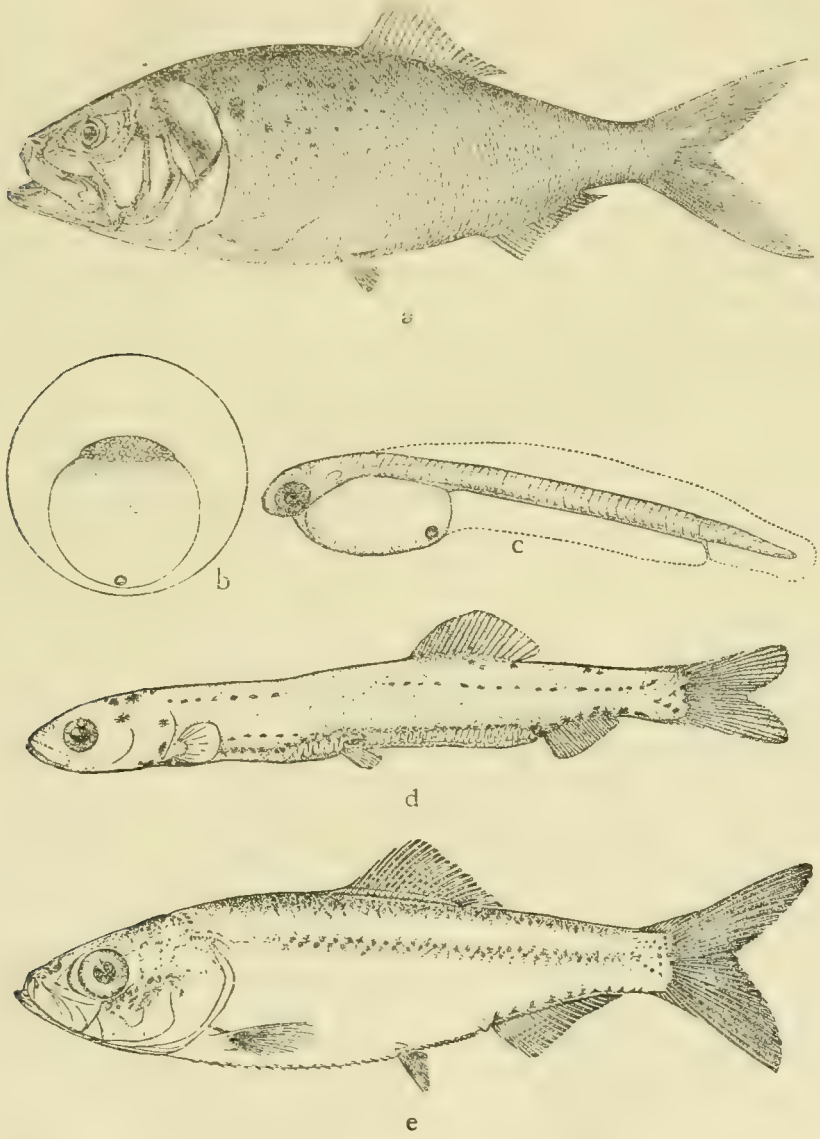

FIG. 48.—Menhaden (*Brevoortia tyrannus*)

a, Adult. *b*, Egg. *c*, Larva, newly hatched, 4.5 millimeters. *d*, Fry, 23 millimeters. *e*, Young fish, 33 millimeters.

Size.—Adult menhaden average 12 to 15 inches in length, and from two-thirds to 1 pound in weight. One 18 inches long was taken at Woods Hole in 1876, and a fish 20 inches long has been reported.

Color.—Dark blue, blue gray, or blue brown above, with silvery sides, belly, and fins, and a strong yellow or brassy luster. There is a conspicuous dusky spot on each side close back of the gill opening, with a varying number of smaller dark spots behind it.

General range.—Atlantic coast of North America from Nova Scotia to Brazil.

Occurrence in the Gulf of Maine.—The Gulf of Maine is the northerly limit of range of the menhaden; St. Mary Bay on the west coast of Nova Scotia is its most easterly outpost. Prior to about 1850 the pogy seems not to have been uncommon at the mouth of the Bay of Fundy; it was, indeed, reported by Perley (1852) as far up the bay as St. John, and fishermen spoke of it as abundant near Eastport up to 1845 or 1850. Since then, however, it seems to have abandoned Fundian waters altogether [25] except for an occasional straggler, and very few menhaden have been noticed east of Mount Desert and Jonesport of late years.

Perhaps the most interesting aspect of the occurrence of the menhaden in the Gulf of Maine is that it fluctuates tremendously in abundance from year to year, periods of great plenty alternating with periods of scarcity or entire absence from our waters. Thus 1845 was a "big year," while in 1847 pogies were very scarce. Then for some years prior to 1875 they were tremendously abundant off the coasts of Massachusetts and Maine every summer, and a considerable menhaden fishery grew up on the Maine coast. Since then the local stock has undergone the most violent fluctuations imaginable, of which abundant testimony is to be found in the files of the Bureau of Fisheries. Thus very few menhaden were taken in the Gulf during the cold summer of 1877 until September and October, when they were reported as about as abundant as normal. Practically none appeared north of Cape Cod in the year 1879, as striking an abandonment of a considerable area by a fish previously abundant there, perhaps, as has taken place within recent times.

For the next six years menhaden were so scarce along the coast of Maine that when odd ones were picked up in the weirs or were seined it caused comment (in 1883, for instance, a few were reported to the bureau but no schools were seen), and many people thought they had gone for good; but in 1886 they were once more reported abundant off Maine and Massachusetts, while in 1888 they were so plentiful as far east as Frenchmans Bay that the menhaden fisheries were revived. Menhaden were as plentiful in Maine waters in 1889 as they had ever been, with more than 10,000,000 pounds taken there, and they were still so numerous in 1890 that four fertilizer factories were established and nearly 90,000,000 fish were taken during the season. This period of abundance was short-lived, however, less than half as many fish being caught in Maine waters (about 41,000,000) in 1891 as in 1890, while few menhaden were taken or seen north of Cape Cod in 1892. In 1894, however, the fish were once more sufficiently abundant in the Gulf of Maine for a single steamer to seine about 1,000,000 fish off the Kennebec during July and the first weeks of August, and 582,131 fish were taken in Boston Harbor in 10 days' fishing during the last half of that month.

[25] According to Huntsman (1922a) one was taken in St. John Harbor in August, 1919.

During the period 1895 to 1897 menhaden were scarce in the Gulf, but abundant again in 1898, about 7,000,000 pounds being taken along the Maine coast. In 1902 the Maine catch fell to only about 300,000 pounds. In 1903, however, they were again reported as very abundant north of Cape Cod, especially in Boston Harbor; but from 1904 to 1921 menhaden were rare north of Cape Cod, and some years a few schools were seined in Massachusetts and on the Maine coast while during other summers very few were seen. After 20 years of scarcity, however, they reappeared in great abundance in the southwest part of the Gulf in the summer of 1922, and by the first week in August many schools had been seen along the outer shore of Cape Cod. Eighteen steamers fished successfully for some weeks in Massachusetts Bay, and menhaden were reported as plentiful at least as far north as Boothbay Harbor, where about 2,500 barrels were frozen. The fact that upwards of 1,500,000 pounds were landed by the larger fishing vessels besides what the small boats brought in will give some idea of their abundance in the Gulf during the summer in question, but no large schools were reported east of Boothbay Harbor.

The appearance of menhaden in such abundance in the Gulf after so many years' absence prompted the Bureau of Fisheries to send the steamer *Halcyon* to Massachusetts Bay in August for an investigation of this phenomenon. A preliminary examination of the towings revealed the presence of much greater quantities of diatoms than is usual at that season, showing that the fish found a better pasture in Massachusetts Bay than in any summer since 1912, but this evidence hardly warrants the definite conclusion that it was an unusually rich food supply that attracted them past Cape Cod.

The menhaden is a summer fish with us, all reports agreeing that in its years of plenty it appears about mid-May in Massachusetts Bay and during the last weeks of May or the first part of June off the Maine coast, and that more and more continue to appear for a month after the first fish arrive. Pogies are most abundant during July, August, and in early September, after which few are seen. Most of them depart from the coast of Maine by the middle of October, and from the Massachusetts Bay region by early November, while by the middle of that month it would be unusual to find a single menhaden along these shores.

The universal belief among fishermen that the seasonal appearance and disappearance of menhaden in the Gulf of Maine result from a definite migration from the south around Cape Cod in the spring and a return journey in the autumn is probably well founded, for, unlike the herring, it is a warm-water fish, and our study of the temperature of the Gulf of Maine corroborates earlier observations to the effect that it never appears in spring until the coastwise water has warmed to 50° or more, or in abundance until the temperature is several degrees higher than this, which is in accord with Bean's (1903) experience that menhaden will not survive in an aquarium if the water chills below 50°. No doubt it is the falling temperature of autumn that forces the menhaden to leave the bays of northern New England.

It is generally believed that the Gulf of Maine fish round Cape Cod and travel westward in their autumn migrations[26] as far as the eastern end of Long Island,

[26] Smith, 1896, p. 299.

where they have been thought to leave the coast and proceed directly out to sea, but this is not established nor is their winter home known.

The menhaden usually hug the shore in summer, most of the catch being taken inside our bays, in the outer harbors, or at the farthest not over half a dozen miles from land, and though this rule has its exceptions—some years they congregate chiefly as much as 40 to 50 miles offshore, 1878 being an instace in point—we have heard no report of menhaden in the central part of the Gulf or on Georges Bank.

In menhaden years the fish occur all along the shores of the Gulf of Maine from Cape Cod to Penobscot Bay, even to Mount Desert, but their chief centers of abundance always lie in Massachusetts Bay within a mile or so of land, particularly off Barnstable and in the mouths of Boston and Salem Harbors, in Casco Bay, among the islands, and thence to Penobscot Bay.

Breeding habits.[27]—Menhaden spawn all along the eastern coast of the United States as far north as the southern part of the Gulf of Maine, the breeding season varying with latitude. Thus spawning occurs in late fall and early winter on the south Atlantic and Gulf coasts, but off the middle Atlantic States menhaden spawn in summer and through the autumn, while captures of eggs and of larvæ about Woods Hole prove that spawning takes place there chiefly in June and continues until well into October. The menhaden is equally a summer spawner in the Gulf of Maine, where spent fish and others approaching maturity have been reported during July and August. Up to the present, however, we have found no eggs in our tow-nettings north of Cape Cod (though young fry were taken in abundance in Casco Bay in October, 1900), probably because our work has been carried on during a series of poor menhaden seasons.

Menhaden eggs are buoyant and resemble those of the European pilchard (*Clupea pilchardus*), but are easily distinguished from the eggs of any other Gulf of Maine fish by their large size (1.5 to 1.8 mm. in diameter), broad perivitelline space, small oil globule (0.15 to 0.17 mm.), and very long embryo. Incubation, as Welsh found by experiment, is very rapid (less than 48 hours). The newly hatched larvæ are 4.5 mm. in length, growing to 5.7 mm. in four days after hatching. The dorsal and caudal fins first become visible at a length of 9 mm.; at 23 mm. all the fins are well developed; at 33 mm. scales are present; and at 41 mm. the fry show most of the characters of the adult though their eyes are proportionately much larger. The youngest larvæ much resemble young herring, but the fins are formed, the tail becomes forked, and the body deepens at a much smaller size, a menhaden of 20 mm. being as far advanced in development as a herring of 35 mm., which makes it easy to distinguish the older larvæ of the two fish.

Welsh concluded from examination of great numbers of fry and from measurements and scale studies of fish of various ages that menhaden spawned in summer (which would apply to most of the fry produced in the Gulf of Maine) are 6 to 8 cm. (2¼ to 3¼ inches) long their first winter and average slightly more than 16 cm. (about 6¼ inches) the second winter, while fall-spawned fish are 3 cm. (1¼ inches) and about 13 cm. (about 5 inches) long in their first and second winters, respectively, with every gradation between the two, depending on the precise season when the

[27] The breeding habits of the menhaden are described by Kuntz and Radcliffe (1918, p. 119).

fish are spawned. Sexual maturity is apparently attained in the season following the third winter, and a few of the older fish that he examined showed as many as 9 to 10 winter rings on the scales.

When the menhaden first arrive on our coasts in spring they are thin, but they put on fat so rapidly that while the average yield of oil per 1,000 Gulf of Maine fish was about 12 gallons for the whole summer season of 1894, it rose to 14½ gallons for Boston Harbor fish in August and to 16 or 18 gallons in September. It is generally accepted, furthermore, that fish taken on the New England coast always average larger and fatter than those caught farther south.

Food.—The menhaden, formerly thought to subsist on mud, is now known to feed chiefly on microscopic plants, particularly diatoms, and on the smallest Crustacea.[28] These it sifts out of the water with a straining apparatus in the shape of successive layers of pectinated gill rakers as efficient as our finest nets. Menhaden feed, as Peck described, by swimming with the mouth open and the gill openings spread, and we have often seen specimens in the aquarium at Woods Hole doing this.[29] The mouth and pharyngeal sieve act exactly as a tow net, retaining whatever is large enough to enmesh with no voluntary selection of particular plankton units. The prey thus captured, as appears from the stomach contents, includes small annelids, various minute Crustacea, schizopod and decapod larvæ, rotifers, etc., but as a rule these are greatly outnumbered by the sundry unicellular plants, particularly by diatoms and peridinians. At a given locality the food eaten parallels the general plankton content of the water, except that none of the larger animals, on the one hand, nor the very smallest organisms (that is, certain infusoria), on the other, appear in the stomachs of the fish. The menhaden, in short, parallels the whalebone whales in its mode of feeding, except that its diet is finer because its filter is closer meshed. Peck has calculated from observations on the living fish that an adult menhaden is capable of filtering between 6 and 7 gallons (about 24 to 28 liters) of water per minute, and while the fish do not feed continuously this will give some measure of the tremendous amount of water sifted and of plankton required to maintain the hordes in which these fish appear. The abundance of microscopic plants in the water of bays, estuaries, etc., has often been invoked to explain the concentration of menhaden close to the shore.

Enemies.—No wonder the menhaden, fat and oily, swimming as it does in great schools of closely ranked individuals and helpless to protect itself, is the prey of every predaceous animal that swims, and that the havoc wreaked on it by other fish has often been described. Whales and porpoises devour them in large numbers; sharks are usually seen following the pogy schools; pollock, cod, silver hake, and swordfish all take their toll in the Gulf of Maine, as do weakfish and bluefish south of Cape Cod. Tuna, or "horse mackerel," kill great numbers, but the worst enemy of all is the bluefish, and this is true even in the Gulf of Maine during periods when both bluefish and menhaden are plentiful there (p. 239). Not only do these pirates devour millions of menhaden every summer but they kill far

[28] For a detailed account of the food and of the branchial sieve of the menhaden, see Peck (Bulletin, United States Fish Commission, Vol. XIII, 1893 (1894), pp. 113–124, pls. 1–8. Washington).

[29] Apparently Ehrenbaum (as quoted by Bullen, Journal, Marine Biological Association of the United Kingdom, Vol. IX, 1910–13, pp. 394–403. Plymouth) was not acquainted with the habits of the menhaden when he wrote to the effect that no fish eat plankton indiscriminately or habitually swim about with open mouth when feeding.

more than they eat. Besides the toll taken by these natural enemies, menhaden, like herring, often strand in myriads in shoal water either in their attempt to escape their enemies or for other reasons, to perish and pollute the air for weeks with the stench of their decaying carcasses.

Habits.—The menhaden, like the herring, almost invariably travels in schools of thousands of individuals, swimming closely side by side and tier above tier when, as Goode, et al. (1884, p. 571) so graphically write, "one may see their glittering backs beneath, and the boat seems to be gliding over a floor inlaid with blocks of silver." In calm weather menhaden come to the surface, where fishermen recognize the identity of the schools by the ripple they make. W. F. Clapp has described the visible difference between menhaden, herring, and mackerel, as follows:

> Pogies, like herring, make a much more compact disturbance than mackerel, which are often much scattered. Pogies make a much bluer and heavier commotion than herring, which hardly make more of a ripple than does a light breeze passing over the water. Besides, the individual pogies or herring seldom show themselves, whereas mackerel often break the surface with their heads while swimming.

It is chiefly on warm, still, sunny days that the menhaden come to the surface -sinking in bad weather—and they are said to come up more often on the flood tide than on the ebb. It is also said—but this we can not vouch for—that the fish work inshore on the flood tide and offshore on the ebb.

Commercial importance.—Commercially the menhaden is one of the most important of our American fishes—not for the table, but for the manufacture of oil and fertilizer[30] –but, as pointed out above (p. 120), it is only in certain years that a large catch is made north of Cape Cod. The fact that the total value of menhaden products in the year 1912 was $3,690,155 will give an idea of the magnitude of the industry. Practically the entire catch of menhaden is taken with purse seines; they never bite a baited hook. Menhaden are used to a very limited extent for food, but so oily a fish is never likely to become popular.

THE ANCHOVIES. FAMILY ENGRAULIDIDÆ

The anchovies are small herringlike fishes, readily distinguishable from the latter by the fact that the mouth is not only very much larger and gapes much farther back, but is inferior in situation rather than terminal, and is overhung by the upper jaw, which projects like a short piglike snout in some species. Only one anchovy, a straggler from the south, is known to occur in the Gulf of Maine.

45. Anchovy (*Anchovia mitchilli* Cuvier and Valenciennes)

WHITEBAIT

Jordan and Evermann, 1896–1900, p. 446.

Description.—The only Gulf of Maine fishes with which one might confuse the anchovy are young herring, smelt, or silversides, but it may easily be distinguished from the former by the wide mouth, as just noted, by the fact that the upper jaw overhangs the lower instead of vice versa, by its much larger eye, by the relative

[30] For an account of the status of the menhaden industry in 1912, see Greer (Appendix III, Report, U. S. Commissioner of Fisheries, 1914 (1915), 27 pp.).

positions of the fins, the dorsal being altogether behind instead of over the ventrals, with the latter originating close behind the tips of the pectorals when these are laid back against the body, by its much longer anal fin, and by the fact that the belly is rounded instead of sharp edged. The lack of an adipose fin back of the dorsal is sufficient to separate anchovy from smelt at a glance, while the silversides (Menidia) has two dorsal fins instead of only one. The anchovy has large, thin, easily detached scales and a deeply forked tail. Its body is about four times as long as deep, and compressed, while the tip of the upper jaw or "snout" is shorter than in most of its immediate relatives.

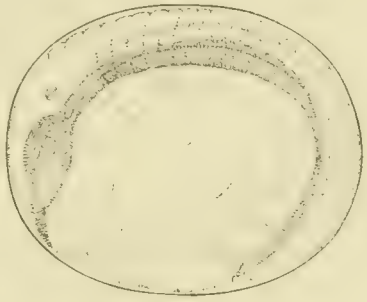

FIG. 49.—Egg

FIG. 50.—Larva, 10 millimeters

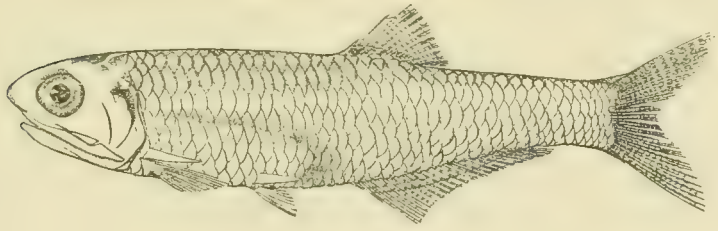

FIG. 51.—Adult

ANCHOVY (*Anchovia mitchilli*)

Color.—The anchovy is a whitish silvery translucent little fish, its most characteristic marking being an ill-defined silvery band scarcely wider than the pupil of the eye running from the gill opening back to the caudal fin. There are also many dark dots on body and fins.

Size.—Two and one-half to four inches long.

General range.—Coast of the United States from Maine to Texas, chiefly west and south of Cape Cod.

Occurrence in the Gulf of Maine.—The anchovy is mentioned here because it has been taken in Casco Bay and at Provincetown. It has no real place in the Gulf of Maine fauna, being a southern fish that rarely strays past Cape Cod, though it is abundant about Woods Hole and thence westward and southward. Stragglers

may be expected most often in the Gulf in midsummer since it appears from May to October in southern New England waters. Sandy beaches and the mouths of rivers are its chief resorts.

Habits.—An account of its embryology and larval development is given by Kuntz.[31]

THE SALMONS. FAMILY SALMONIDÆ

The salmons are soft-rayed fishes with no spines in any of the fins, with the ventrals situated on the abdomen far behind the pectorals, and with a fleshy rayless "adipose" fin on the back behind the rayed dorsal fin, the presence of this adipose fin and its location separating them from all other Gulf of Maine fishes except the smelt family, the pearlsides (p. 151), and the viper and lancet fishes (p. 155).[32] The rounded noses, stout bodies, and nearly square tails of the salmons mark them at a glance from the sharp-nosed, slender, forked-tailed smelts; the absence of phosphorescent organs distinguishes them from the pearlsides, while the viper and lancet fishes are of quite different general aspect. At the present time three salmons[33] occur in the Gulf of Maine, one of which—the sea trout—resorts to tidal estuaries at the mouths of a few of our streams, while a second—the humpback salmon—has recently been introduced from the Pacific coast (the success of the experiment is still in doubt), leaving the Atlantic salmon alone as a characteristic inhabitant of the open waters of the Gulf of Maine.

KEY TO GULF OF MAINE SALMONS

1. Anal fin long, with 14 to 17 rays ..... Humpback salmon, p. 126
   Anal fin short, with less than 13 rays 2
2. Scales so small as to be hardly visible; back with vermiculate markings; teeth on roof of mouth confined to a group in front ..... Sea trout, p. 138
   Scales large enough to be easily visible; back without vermiculate markings; a row of teeth runs back along the midline of the roof of the mouth ..... Salmon, p. 130

46. **Humpback salmon** (*Oncorhynchus gorbuscha* Walbaum)

Jordan and Evermann, 1896–1900, p. 478.

Description.—The humpback is of the familiar salmon outline while living in the sea, the body being deeper than thick but with rounded belly. (See fig. 52, p. 129.) The head is naked but the body is covered with scales large enough to be seen easily. Its dorsal fin stands about midway of the body above the ventrals, and the flaplike adipose fin is over the rear end of the anal. In all this it agrees so closely with the Atlantic salmon that the two might easily be confused were it not that the anal fin of the humpback invariably has 14 or more rays while that of the Atlantic salmon has only about 9. The male humpback, like all the Pacific salmons and to a lesser degree the Atlantic salmon, undergoes a very noticeable change in form in the spawning season, when the body deepens and develops a prominent hump in front of the dorsal fin, while the jaws elongate and become hooked at the tip and the teeth increase in size.

[31] Bulletin, U. S. Bureau of Fisheries, Vol. XXXIII, 1913 (1915), p. 13.

[32] Sundry other deep-sea fishes have adipose fins.

[33] A specimen of one of the whitefishes (probably *Coregonus quadrilateralis* Richardson) was taken in the mouth of the Sissibou River, St. Mary Bay, September, 1919 (Huntsman, 1922a, p. 11), straying down from fresh water. Whitefish are recognizable by the presence of an adipose fin, as in the true salmons, but a very small mouth and compressed, herringlike rather than salmonlike body.

Color.—While in the sea the back and tail of the humpback are bottle green with poorly defined black spots. These spots are particularly conspicuous on the tail, where they are oval in outline and as much as a third of an inch across the long diameter. These large oval spots on the tail form one of the most distinctive marks whereby the humpback can be distinguished from all other salmon. Its sides and belly are silvery, with a faint pinkish tinge. Young humpbacks are unique among salmon in being of practically adult coloration without "smolt" marks (p. 133).

Size.—The humpback is the smallest of the Pacific salmons and is much smaller than the Atlantic salmon, adults averaging only about 5½ pounds in weight and 20 to 25 inches in length, males running up to about 11 and females to 7½ pounds.

General range.—Pacific coast and rivers of North America and Asia, from Oregon northward on the American side. This is the most abundant salmon in Alaska. It runs up fresh rivers to spawn, which it does but once and then dies.

Occurrence in the Gulf of Maine.—The history of the introduction of this west coast salmon to New England waters is as follows:

In the autumn of 1913 a large consignment of humpback eggs was shipped to the Craig Brook and Green Lake (Me.) hatcheries, and the approximately 7,000,000 fry and fingerlings hatched therefrom were distributed in the Penobscot, Androscoggin, Damariscotta, Dennys, Pleasant, Union, Medomak, Georges, and St. Croix Rivers. A year later some 5,000,000 more young fish were liberated. A third plant was made in 1915, a fourth of 6,235,808 fingerlings in 1916, and a fifth of about 1,000,000 in the Dennys and Pembroke Rivers in 1917.[34] The results of this attempt at acclimatization were first seen in the summer and fall of 1915 when fishermen along the Maine coast reported large numbers of mature humpbacks. Furthermore, humpbacks ran in the Dennys River (where many were caught) from August 15 until September 24, and some probably spawned there, for the bodies of spent fish were seen drifting downstream. Humpbacks again entered the rivers of eastern Maine, particularly the Pembroke and Dennys, with a few reported from the Penobscot, St. Georges, Medomak, and St. Croix, during August, September, and October, 1917, the result of the plant of 1915. In the Dennys alone at least 2,000 mature fish were seen and many averaging about 5 pounds and one as heavy as 10 pounds 9 ounces were caught. Definite information for 1918 is lacking, but even larger numbers entered the Dennys and Pembroke Rivers in the autumn of 1919 than in 1917, with smaller runs in the Penobscot, Machias, St. Croix, and Medomak Rivers, and humpbacks were caught in weirs in Passamaquoddy and Cobscook Bays near the mouth of the Bay of Fundy. Enough spawned in the Dennys and Pembroke Rivers that year for the fish-culturists of the Bureau of Fisheries to artifically fertilize half a million eggs.

In 1920,[35] too, adult fish were taken in the weirs in Penobscot Bay, and some time during the summer of 1921 one fish was caught in a weir as far from its native river as Lanesville, Mass. (near Cape Ann), whence it was forwarded to the Massachusetts commissioners as reported by C. E. Grant, of Gloucester.

[34] More detailed accounts of the successive plantings will be found in the annual reports of the Commissioner of Fisheries for the years 1914 to 1920.

[35] Reported catch, Washington County, Me., 1920, 310 pounds.

The experiment has gone far enough to prove that the humpback can live and grow in the Gulf of Maine during its normal period of marine existence and find its way back to the home streams as the time of sexual maturity draws near. Whether it can multiply to any considerable stock, or even maintain itself by natural reproduction without the aid of artificial propagation in the few Maine rivers open to it, remains to be seen. Brief experience with it in the Gulf of Maine suggests that the local run will take place in late summer and early autumn as is the case in Alaska.

Habits.—The humpback runs up small streams indifferently, whether or not lakes occur in their courses. After it enters fresh water it feeds no more, and its digestive organs, like those of all Pacific salmons, shrivel up and atrophy while the changes in form of body and jaws, so characteristic of the breeding male (p. 126), take place. The skin, too, thickens and becomes so spongy that the scales are entirely concealed. The humpback spawns very soon after it enters the rivers, and though it reaches the spawning grounds in fairly good condition (except for a loss of fat), the fins of both sexes soon become frayed, the skin rubs off the jaws, bases of fins, and other prominent places, the tails of the females are worn down to the quick, fungus attacks these open wounds as well as the gills and eyes, and when the last eggs and milt are deposited the spent and exhausted fish finally die. No humpback ever survives the operation of spawning.

Spawning takes place in the fall at temperatures of 54° to 60° F. As soon as the yolk sac of the young humpback is absorbed and it is able to swim (which is about the time the ice breaks up in spring) it runs down to the sea. During their first months in salt water the fry linger near the mouths of the home streams,[36] where they feed chiefly on copepods and other small crustaceans, on pteropods, and on insects that drift downstream with the current, and occasionally on fish fry. After they are 5 or 6 inches long they move out into deep water, and very little is known of their habits and wanderings thereafter until they reappear on the coast as adults to breed. Large humpbacks have been found full of pelagic Crustacea and launce, evidence that they subsist on a mixed plankton and fish diet, the former probably predominating. No humpback has ever been known to take a trolled spoon or baited hook.

McMurrich [37] (in 1912) and Gilbert [38] (in 1913) have proved by their studies of its scales that the humpback invariably lives in the sea through one summer, a winter, and well into the second summer, and then comes in to spawn.

Commercial importance.—The humpback is an excellent food fish when taken in salt water and would be a valuable addition to the Gulf of Maine, but it becomes worthless soon after entering fresh water.[39]

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[36] We owe to Chamberlain (Bureau of Fisheries Document No. 627, Report, U. S. Commissioner of Fisheries, 1906, 112 pp., Pls. I–V) the little we know of the habits of the young humpback.

[37] Proceedings and Transactions, Royal Society of Canada, Third Series, Vol. VI, May, 1912 (1913), Section IV, pp. 9–28.

[38] Bulletin, U. S. Bureau of Fisheries, Vol. XXXII, 1912 (1914), pp. 3–22, Pls. I–XVII. Washington.

[39] The Pacific "chinook" salmon (*Oncorhynchus tschawytscha*) was introduced in the Merrimac River system by the Commissioners of Fisheries and Game of the State of Massachusetts in 1916, but the plant seems to have been a failure, for no adults were reported in 1920, the year they would have been expected to return from the sea as mature fish.

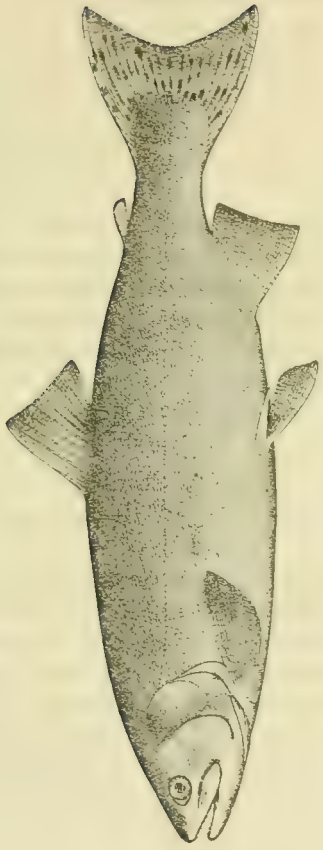

FIG. 52.—Humpback salmon (*Oncorhynchus gorbuscha*)

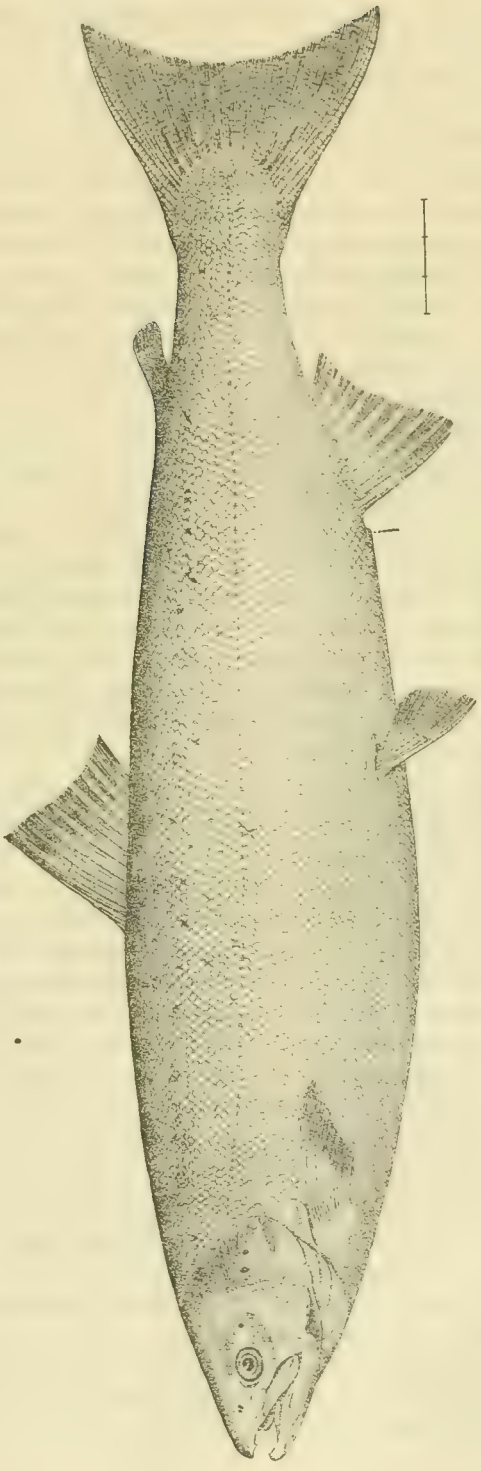

FIG. 53.—Atlantic salmon (*Salmo salar*)

47. **Salmon** (*Salmo salar* Linnæus)

ATLANTIC SALMON; SEA SALMON; PARR; SMOLT; GRILSE; KELT

Jordan and Evermann, 1896–1900, p. 486.

Description.—The Atlantic salmon is a more slender and graceful fish than the humpback—about one-fourth as deep as long, deepest below the dorsal fin, whence it tapers toward both head and tail. It is oval in cross section. Its head is small (about one-fifth, or less, of the total length, not counting caudal fin), its nose is pointed, the eye rather small, and its mouth gapes back to below the eye. The dorsal fin (about 11 rays) stands about midway between the tip of the snout and base of tail fin; the ventrals are under its rear end. The anal is similar in form to the dorsal but with only about 9 rays (7 to 10 have been recorded), whereas the humpback has 14 or more. In adults the tail is only very slightly emarginate; almost square in large fish. In fish only one year at sea, however ("smolts" and "grilse"), it is more forked.

Teeth.—The teeth afford the most certain distinction between small salmon and the New England sea trout (Salvelinus, p. 138), for in the former the roof of the mouth is armed not only with a cluster in front but with a row of stout conical teeth running back along its midline, easily felt with the finger, whereas the sea trout has the anterior group only. Old salmon sometimes lose these "vomerine" teeth, but the large size of the fish identifies them at a glance.

Scales.—The scales are large—a diagnostic feature for small fish—those of the sea trout being hardly visible (p. 139).

Color.—While in the sea the salmon is silvery all over, with brownish back and marked on head, body (chiefly above the lateral line), and fins with numerous small black crosses and spots.

Weight of salmon in the Gulf of Maine.—The largest salmon we find mentioned was an English fish of 83 pounds. None even approaching this size is recorded from our side of the Atlantic, where a 50-pounder is unusual, though fish of 40 pounds weight are not uncommon in some of the larger rivers emptying into the Gulf of St. Lawrence. In the Penobscot and St. John Rivers very few fish reach 40 pounds and 30-pounders are rare, the usual run being 10 to 12 pounds. Taking one river with another, large and small, 10 pounds may be set as a fair average of the mature Gulf of Maine fish. With due allowance for individual and seasonal variation a 2-foot fish will weigh about 6 pounds; one of 3 feet, 16 to 20 pounds.

General range.—Coastal waters of both sides of the North Atlantic to within the Arctic Circle, entering rivers to spawn. On the American coast salmon formerly ran up all suitable rivers from northern Labrador to the Housatonic River in Connecticut and possibly the Hudson also.

Occurrence in the Gulf of Maine.—When the white man first came to New England he found salmon in every large stream not barred by impassable falls from Cape Sable to Cape Cod; that is, all the Nova Scotian and New Brunswick rivers tributary to the Gulf of Maine, and the following rivers in New England: St. Croix, Dennys, Orange, East Machias, Machias, Pleasant, Narraguagus,

Union, Penobscot, St. George, Medomak, Sheepscot, Androscoggin, Kennebec, Royal, Presumpscot, Saco, Mausam, Piscataqua, and Merrimac.[40] Since the beginning of the past century, however, one New England river after another was so obstructed by dams that by 1887 salmon regularly entered the St. Croix, Dennys, East Machias, Machias, Penobscot, Sheepscot, Kennebec, and Androscoggin only. The Kennebec was still an important salmon river as late as 1895, but at present the Penobscot and Dennys alone see a regular run, though odd salmon still enter other streams. Along the Canadian shores of our Gulf a few salmon still run in the Tusket, Salmon, and Annapolis Rivers, many in the Shubenacadie River in Nova Scotia, some in the Petit Codiac, and great numbers in the St. John in New Brunswick, the latter still being a famous salmon river, while odd fish are seen in the St. Croix now that the sawdust pollution is not as bad as formerly.

The fate of the salmon in the Merrimac[41] typifies its history in the rivers from which it is now barred. Salmon spawned plentifully in the upper tributaries of the stream in question, especially the Pemigewasset, as late as 1793 (in 1790 the run was so abundant in the lower river that 60 to 100 a day was the usual catch with a 90-yard seine near the mouth at Amesbury), but from that time on, with the construction of one dam after another, the run of salmon steadily dwindled until in 1847 the completion of the dam at Lawrence completely barred the upper reaches of the river. For some years thereafter salmon congregated below this dam in spring and summer vainly endeavoring to surmount it, but since 1859 or 1860, by which date the last salmon hatched above had lived its span of life, there has been no run of salmon in the Merrimac nor have any spawned there with the possible exception of a few lifted over the dam by hand. Nevertheless a few salmon have been seen and caught in the lower Merrimac year after year. There were, indeed, enough of these fish to yield a supply of eggs for artificial hatching up to 1893, but attempts at restocking by this means have proved vain and will until proper fishways are provided at all the dams. In 1896 there seems to have been what almost might be described as a "run"—for salmon were seen leaping below the Lawrence dam nearly every day from June 10 to July 25, often 10 or 20 at a time, and a few were lifted over—but this proved merely a flurry, for only a few were seen in 1898, 6 only (at Lowell) in 1899, 7 in 1900, 11 in 1901, and since then not a single Atlantic salmon has been credibly reported in the Merrimac, although the director of the Massachusetts Division of Fisheries and Game has made special inquiry of the local wardens.[42] Nor is it likely that salmon would still run in the Penobscot were it not for the artificial propagation carried on there by the United States Bureau of Fisheries, so seriously is the river obstructed.

The early extirpation of salmon from so many New England rivers naturally resulted in a great change in the distribution of salmon in the open Gulf, clearly reflected in the catch. Thus in 1889 more than 150,000 pounds (about 15,000 fish) were taken in the weirs and traps along the Maine coast and in its river mouths

[40] Atkins (1887, p. 679) has collected much information on the local history of salmon in northern New England.

[41] Lyman and Reed, 1866, pp. 3–41.

[42] One or two small "salmon" that have been caught were probably landlocked, running down from tributaries stocked with this fish.

(more than seven-eighths of this in or about the approaches to the Penobscot River), while as recently as 1905 the catch for Maine was more than 86,000 pounds (of this 74,000 pounds, or 6,378 fish, were from the Penobscot), but by 1919 the Maine catch had fallen to little more than 20,000 pounds with only odd fish taken off Massachusetts. As 70 to 90 per cent of the Maine catch comes from Penobscot River or Bay, the following table of salmon caught there since 1905 is pertinent:[43]

Year	Number of fish	Pounds	Year	Number of fish	Pounds
1896	6,404	80,225	1905	6,378	74,158
1898	3,225	42,560	1918	1,653	17,212
1901	6,821	86,055	1919	1,322	13,557
1903	4,859	67,470	1920	1,598	15,135

On the other hand, there are actually more salmon to-day in the Canadian waters of the Gulf than there were 30 years ago, thanks to wise measures of conservation such as limiting netting at the mouths of the rivers and keeping them free of access by fishways at the dams; so much so, indeed, that it is safe to set the total yearly catch for the whole Gulf as 50 per cent larger now than during the period about 1890, as appears from the following statistics:

Locality	1889 [1]	1916–17 [2]	Locality	1889 [1]	1916–17 [2]
	Pounds	*Pounds*		*Pounds*	*Pounds*
Nova Scotian shores of the Gulf of Maine and the Bay of Fundy	74,523	264,900	Coast and rivers of Maine	152,740	[3] 20,000
New Brunswick shore of the Bay of Fundy	155,578	381,500	Coast of Massachusetts north of Cape Cod	139	[3] 100
New Brunswick rivers tributary to the Bay of Fundy	43,500	83,400			

[1] The Canadian and United States returns for 1889 are directly comparable, both being for the calendar year, but the Canadian returns for 1916–17 were for the fiscal year Mar. 31 to Mar. 31.
[2] The Canadian catch was larger the year previous.
[3] Approximate.

A catch of 250,000 to 300,000 pounds (about 25,000 to 30,000 fish) may now be expected annually along the Canadian shores and in the Canadian rivers of the Gulf; in New England waters less than 20,000 pounds. Fishery by modern methods no doubt would have yielded a very much larger total in past times when the fish ran in all the New England rivers.

Although no salmon now spawn south of the Penobscot a few are still taken every summer in the weirs in the Massachusetts Bay region. Up to about 1895 Cape Cod Bay annually yielded a number of large fish weighing up to 25 pounds or more, as well as many young smolts of about 6 inches (p. 133), with 1892 as a particularly productive year. A few fish were taken yearly about Cape Ann, also, and in Cape Cod Bay until about 1908. Thereafter the Massachusetts catch fell practically to nil. In some seasons an odd fish or two was reported from one place or another in the Massachusetts Bay region, other years none at all,[44] until 1917 when perhaps 150 small salmon of from 2 to 5 pounds were caught by the mackerel gill-netters in Ipswich Bay and off Thachers Island during November and early December.

[43] Radcliffe, 1921, p. 146.
[44] For further data on salmon in Massachusetts waters see the annual reports of the Massachusetts commissioners since 1902.

Life history.—It is no wonder that the life of as noble a fish as the salmon has been the subject of much scientific study and that a whole literature has grown up about it. As everybody knows the salmon lives the greater part of its life and makes most of its growth in the sea but spawns in fresh water. In Gulf of Maine rivers this happens in October and early November on sandy or gravelly bottom far upstream, the females smoothing a shallow trough and covering the eggs with gravel. The large (6 to 7 mm.) thick-shelled eggs lie loose on the bottom and develop so slowly in the low temperature of winter that hatching does not take place until late in the following April or early in May. The newly hatched larvæ are 15 to 18 mm. (0.6 to 0.7 inch) long, and carry a tremendous large yolk sac for about six weeks, hiding among the pebbles of the spawning bed and taking no food. When the yolk sac is absorbed the little fish begin to swim and feed. These little salmon, known as "parr," soon assume a brilliant coat with 10 or 11 dark transverse bars alternating with bright red spots, much like a young trout.

Parr live in fresh water for longer or shorter periods, according to locality or to other factors not well understood. In the rivers tributary to the Gulf of Maine probably most of them remain two winters and two summers, running down to sea the third summer, but some may seek salt water toward the end of the second summer (when 1½ years old), as is the rule in rivers tributary to the Gulf of St. Lawrence. Parr may be moving downstream any time from late spring to autumn, but in Gulf of Maine streams most of them probably make the journey in June and July, being then 5 to 6 inches long. On the other hand it is possible that some may linger in fresh water until 3, 4, 5, or even 6 years of age, as is known to happen in Norway. An occasional male parr may even become sexually mature before visiting the sea at all.

As they near tidewater the parr put off their barred and spotted pattern to assume the silvery coat worn by the salmon during his sojourn in the sea. They are then known as "smolts." After they reach salt water they are found for a time about the shores of estuaries and in river mouths. No doubt the little salmon, too small to sell, that are caught in summer and autumn in weirs at Matinicus Island come from the Penobscot a month or two previous, but they leave the coast in autumn and little is known of their movements during the first winter. Smolts from 7 to 12 inches in length have occasionally been taken in drift nets in Norwegian waters and in the North Sea with herring, mackerel, and other fish, suggesting that they follow and prey upon the shoals of the latter, but there is no reason to suppose that they move far offshore. However this may be, they grow so rapidly on the abundant diet the sea affords that they usually reach a length of at least 16 inches and weigh anywhere from 1½ to 7 or more pounds by the following spring when they reappear on the coast. They are now termed "grilse," distinguishable from the older fish by a more forked tail, more slender form, smaller head, thinner scales, and rounded and more numerous spots that are bluish rather than black. Some of the male "grilse" become sexually mature, and although fewer female salmon mature until older, "grilse" of this sex (fish only one year at sea) accompany the males and the older mature fish up the rivers. In northern Canadian streams grilse are very abundant. This is also the case in the St. Johns

but for some unknown reason it appears that so few fish return to fresh water along the coast of Maine until older that in past times when there was still a good run of salmon not more than 3 or 4 grilse to 70 adults were taken in the St. Croix, and not more than 1 to 500 in the Dennys and Penobscot Rivers.

Salmon, like most other northern sea fish, make most of their growth during the summer. In summers when they spawn they hardly grow at all, but unlike the herrings, cod, etc., all mature salmon do not spawn. Hence the size of a salmon depends more on the number of times it has spawned than on its age. Some males, as just remarked, spawn after one year at sea; most of them, and many females, after two; while other fish stay at sea for three, four, or even five years without spawning, meanwhile growing to a great size, and it is probable that all the exceptionally large fish are maidens entering fresh water for the first time. On the other hand salmon that commence spawning at an early age and spawn every year never grow large, for the yearly growth is hardly more than enough to make up for the loss during the sojourn in the river. Salmon rarely live more than eight or nine years or spawn more than three or four times. Many (particularly the very large fish) spawn but once, others annually, and others at intervals of two or three years. It follows from this that large salmon are to be found in the sea throughout the year, though fewer of them in summer when the spawning fish are absent about their reproductive duties than in winter when the whole stock, except for the parr and a few spent fish to be mentioned later, is assembled there.

Food.—The salmon is purely carnivorous and very voracious, feeding altogether on live bait, chiefly on fish and crustaceans. Among the former launce, herring, capelin, smelt, small mackerel, small sculpins, and even flatfish have been described as entering into its diet, with the first three its favorites.[45] Comeau,[46] for example, speaks of launce and capelin as having been the chief diet of thousands of salmon that he opened on the north shore of the Gulf of St. Lawrence. In the Baltic a hook and line fishery is carried on for salmon with herring as bait, and occasionally they have been taken on herring-baited cod trawls off the Maine coast, while herring up to 5 inches in length have been found in salmon stomachs about Eastport. Sand fleas (Gammarus) rank with launce and herring in importance as salmon food in the North and Baltic Seas, while fish entering the Penobscot have been found full of "shrimp" (probably euphausiids). Salmon are also credited with eating crabs.

Most of the large salmon, like the smolts, disappear from the immediate neighborhood of the coast in winter, but probably the main body does not go far to sea, for they are regularly caught near land in the Baltic in winter by the hook and line fishery just mentioned, nor is it unusual for a few salmon to be picked up about Massachusetts Bay at that season, evidence strengthened by the fact that salmon appear about the river mouths so soon after the ice goes out in spring that they can not have come from any great distance. With odd fish entering the river

[45] Eichelbaum (Conseil Permanent International pour l'Exploration de la Mer, Rapports et Procès-Verbaux, Vol. XXI 1916, p. 84) examined the contents of the stomachs of many salmon from the Baltic and North Seas.

[46] Life and Sport on the North Shore, by Napoleon A. Comeau. 440 pp., illus., 1909. Quebec.

mouths in winter (as has often been reported) and with kelts (p. 136) on their way down, salmon are to be found in the large rivers in every month in the year, as has long been known for the Penobscot.

There is no reason to suppose that the Gulf of Maine salmon regularly descend to any great depth, winter or summer. On the contrary, the weirs, gill nets, etc., which yield so many in various regions, are all operated in shoal water (the Baltic hook-and-line fishery is carried on at about 1½ fathoms); but the fact that salmon are caught occasionally on cod trawls in the Gulf is proof that at least some go as deep as 25 fathoms or more, while diet proves they not only feed pelagically, as when pursuing herring, but near if not actually on bottom, where alone they could find Gammarus in abundance.

The view now generally held that the whole body of salmon, whether or not destined to breed that season, moves inshore in spring no doubt applies as well to the Gulf as to other seas. Only fish approaching sexual maturity (irrespective of age), and the immature female "grilse" already mentioned, run far up into the rivers, all others remaining in salt water or at most not running above the head of tide, as has often been remarked. This vernal journey toward the coast takes place long before the spawning season, odd fish even entering the Penobscot in March or earlier, and salmon are to be expected in its lower reaches after the first week of April. Fish apparently coming in from sea are taken off the mouth of Penobscot Bay through May and June and into early July, corresponding to the fact that the chief runs in the Penobscot River itself occur in May and June, with a few fish entering even later. Salmon enter the Nova Scotian rivers beginning late in April, and the New Brunswick streams tributary to the Bay of Fundy from May on. In the Shubenacadie grilse are said to run from August until late in autumn. We have not been able to obtain more definite dates for the St. John River.

A good deal of discussion has centered about the question as to whether the earliest fish stay in fresh water from then until spawning time, a matter of six months, or whether there is more or less movement in and out of the river mouths at the beginning of the season. Probably the latter view is correct, at least for the smaller streams, but it seems safe to say that after the run is well under way in late May or early June no fish return to the sea until autumn. Tagging experiments carried out in Canadian rivers have yielded the very interesting information that no matter when a salmon runs upstream one year, it may do so either early or late the next.[47]

Whether or not salmon feed in fresh water has been a much mooted question on which we have no first-hand information to contribute. Certainly, most students and practical anglers believe that salmon feed little in fresh water and not at all as the spawning season approaches, though they may occasionally snap up a minnow or other tempting morsel while still fresh run. The maturing salmon of both sexes lose their silvery sheen in fresh water during the summer months, to take on a dull brownish or reddish hue, while the belly suffuses with some tint of red, large black spots develop, and the male not only becomes variously mottled and spotted with red or orange, but his jaws elongate, the lower becoming so hooked that only the tips come

[47] Fifty-fifth Annual Report of the Fisheries Branch, Department of Marine and Fisheries, Canada, 1921–22 (1922), p. 19.

together. His body becomes slab-sided, his fins thicken, and his skin is covered with slime, until altogether he is but a disgusting caricature of the beautiful creature that came in from the sea.

Salmon run far upstream—for more than two hundred miles in the larger rivers such as the St. John. Spawning, which occupies the fish from 5 to 12 days, takes place in late October and early November in Penobscot and St. John waters; probably at the same time in Nova Scotian streams. Most of the spent fish—now known as "kelts"—return at once to the sea after spawning, this being true of all grilse kelts and of adult fish in small rivers. Probably most of the large salmon that were formerly taken during the winter in Belle Isle Bay, about 30 miles above the mouth of the St. John River at the head of tide, were kelts, for they have been described[48] as improving in condition with the advance of the season on a bountiful diet of small fish. Some nonbreeding fish seem also to have wintered there,[49] however, held by the same attraction. In large rivers, however, some of the kelts linger over winter, taking little food but nevertheless improving somewhat in condition, to go back to salt water (if they survive, which many of them do not, for spawning leaves them very thin and exhausted) the following spring, when a few such are caught among the sea-run fish that they pass on their way downstream. None of these late kelts spawn the following autumn; annual spawners are to be sought among those that run down immediately after spawning and thus have time to recuperate in the sea. Correspondingly it has been found that a far larger proportion of the fish in small streams than in large are annual spawners. And here we find one even if not the only reason for the well-known fact that salmon invariably average smaller in the former than in the latter, for kelts returning to the sea immediately after spawning have less opportunity to grow (though they recover condition sufficiently to spawn again the following summer) than such as await the spring to go downstream, and that spend a whole year at sea instead of one winter only between two successive spawnings. This, however, does not account for the fact that it is almost invariably in large rivers that the very large maiden fish, four or more years old, are taken, nor can we subscribe to the oft-advanced explanation that smolts from large rivers wander farther out to sea than do those from small ones and hence are longer in returning thence, for once in the salt water of the open sea, salmon are subject to similar surroundings, irrespective of the size of their parent streams.

The distribution of the catch of salmon in the Gulf of Maine yields a glimpse of the movements of the fish there. To begin with, so few are caught near Cape Sable that there can be no general movement around the Cape by the fish that spawn in the rivers of the outer coast of Nova Scotia. The precise locations where salmon are taken in St. Mary Bay (16,400 pounds, or about 1,600 fish, in 1916–17) suggest that the fish follow its southern and not its northern shore on their journeys in and out.[50] Statistics of much larger catches in the Bay of Fundy corroborate Huntsman's (1922a) suggestion that on leaving the rivers they follow the coast (New

[48] Phair. Forest and Stream, Vol. XXX, 1888, p. 291.
[49] Harding, Jas. A. *Ibid.*, Vol. XXXVI, Feb., 1891, p. 68.
[50] A few are also taken near the mouth of the Tusket.

Brunswick or Nova Scotia, as it happens) for some distance out toward the mouth of the bay and then scatter, to return again in spring by the same route. Thus, to go more into detail, very few are caught on the Nova Scotian side between the entrance to St. Mary Bay and Digby Gut, but fish on their way to the Shubenacadie River system from the sea yield an abundant harvest as they follow the shores of Annapolis and Kings Counties (the Annapolis River also yields a few fish in its lower course, as well as an odd one occasionally in the Annapolis Basin). Salmon similarly en route to the St. John, the premier Gulf of Maine river, strike the coast about Point Lepreau (about 23 miles west of the St. John), supporting an important fishery from there to the mouth of the river; but very few St. John River salmon can go up the Bay of Fundy after they leave the river, for hardly any are taken on the New Brunswick shore east of its mouth except for small catches made off the Petit Codiac River near its head, the product of the local run in that stream. A similar trend of salmon out toward the southwest and back along shore in the opposite direction seems to obtain on the coast of Maine, for only an occasional fish, probably the product of the Dennys River, is caught east of Mount Desert, while several times as many, which may safely be credited to the Penobscot, are caught along the stretch of coast line from Penobscot Bay to Cape Elizabeth.

On the whole, the salmon may be looked upon as rather a local fish in these waters; probably few of them stray very far from the streams to which they resort for spawning, nor is it likely that many of the St. John River or Minas Basin fish ever venture far outside the Bay of Fundy into the open Gulf. Perhaps a 50-mile radius would encircle the wanderings of the majority except, perhaps, in winter, when we know nothing of their comings or goings. Marked salmon, however, occasionally have been known to make long migrations on the other side of the Atlantic, while fish marked in Nova Scotia have been taken in Newfoundland. Proof that salmon may stray equally far in the Gulf of Maine is afforded by the yearly captures near Cape Ann and in Massachusetts Bay of fish that must have come from at least as far as the Penobscot River, if not from the Bay of Fundy, and by the fact that odd salmon, either strays from the Gulf or (less likely) the product of the periodic attempts to restock the Hudson, are caught almost every year about Marthas Vineyard;[51] while odd salmon, probably of the latter parentage, have been taken in the pounds along the New Jersey coast. Even young fish may travel for considerable distances during their first summer at sea, since "smolts" so small that they must have run down to salt water but a few months previous, and for which no nursery existed nearer than the Penobscot, have been taken in Cape Cod Bay in October (p. 132). No salmon has ever been creditably reported more than about 25 miles from the nearest land in the Gulf of Maine, and therefore the 100-fathom contour incloses practically the entire range of the species there.[52]

A question closely bound up with the migrations of the salmon in the sea is: What proportion of them return year after year to spawn in the very rivers in which they were hatched? It has been demonstrated by a variety of evidence, especially

[51] Notably in the spring of 1918 when about 75 (including large fish up to 35 pounds) were taken at Gay Head and in the neighborhood of Woods Hole.

[52] Smith (1895, p. 99) records one caught 50 miles at sea off the coast of Delaware.

by the recapture of tagged fish, that the majority of salmon do so return year after year, a thesis generally known as the "parent stream theory." However, since marked fish have occasionally been retaken in strange rivers, as noted above, and since odd salmon appear yearly in certain streams where none have been hatched for many years—in the Merrimac, for instance—it is equally certain that the "parent stream" theory does not always hold. Probably the truth of the matter is that while the great bulk of the fish never strays far and thus readily returns to the home stream, wanderers that chance to be in the physical state leading to maturity when they come inshore in the spring enter any large unpolluted stream they encounter, however far from home.

Enemies.—No doubt when they first go to sea the smolts fall prey to any large predaceous fish—they have, indeed, been found in the stomachs of pollock—but after one or two years' sojourn in salt water salmon are so heavy and strong that only fish as large as tuna, swordfish, or the larger sharks can menace them. Their worst enemy is the harbor seal, which is a common denizen of the northeastern coasts of the Gulf of Maine.

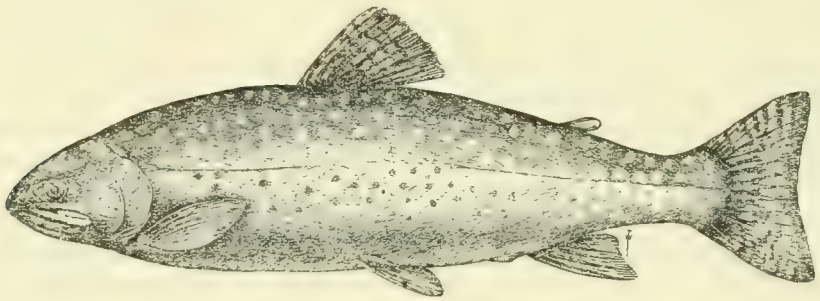

FIG. 54.—Brook trout (*Salvelinus fontinalis*)

48. **Brook trout** (*Salvelinus fontinalis* Mitchill)

SEA TROUT; SALTER

Jordan and Evermann, 1896–1900, p. 506.

Description.—Although brook trout vary widely in general form in different streams, when taken in salt water they are usually salmonlike in shape—that is, with stout bodies usually about one-fourth as deep as long and tapering gracefully to a small head. The nose of a trout, however, is blunter than that of a salmon, and its head is longer in proportion, the total length of the fish (not counting the caudal fin) being about four and one-half times that of the head,[53] while its mouth (gaping back of the eye) is relatively larger. The general arrangement of the fins, including the "adipose," parallels that of the salmon, but the ventral fins stand under the middle of the dorsal—that is, they are farther forward in relation to the latter than in its larger relative. All the fins, too, are relatively larger, particularly the ventrals. As a rule the anal has one fewer ray (usually 8), but the number of dorsal rays (about 11) is the same. The tail of the sea trout is less forked than that of a young salmon of equal size.

[53] Some trout are even longer headed.

Examination of the teeth is the most positive means of distinguishing trout (in European terminology this is a "charr") from salmon smolt, for the vomerine teeth of the trout are confined to a cluster near the front of the roof of the mouth instead of extending backward in a row along its midline as they do in the salmon. Furthermore, the scales of the trout are so tiny as hardly to be visible while those of the salmon are easily seen.

Color.—Trout living in salt water are colored very differently from their fresh-water brothers, for they almost wholly lack the yellow and red tints so conspicuous on the latter but are invariably silvery. Sea-run fish are steel blue or bottle green on the back, with cheeks and sides silvery like a salmon and with a white belly. The sides above the lateral line are more or less dotted with pale yellow spots, but the dark vermiculate markings so characteristic of the fresh-water brook trout are hardly to be seen on the trunk, though evident as wavy crossbars on the dorsal and on the corners of the caudal fins. Below the level of the lateral line the sides and flanks are strewn with small pale vermilion dots but the ventral fins are plain white, or at most the pink edging so conspicuous in trout caught in fresh water is faint.

General range.—Eastern North America, north to Labrador, west to Minnesota, and southward along the Allegheny Mountains to Georgia.

Occurrence in the Gulf of Maine.—Trout are plentiful in many of the river systems and smaller streams that empty into the Gulf of Maine. In some of these some of the trout seek salt water after the breeding season, to remain there over the winter. This applies particularly to the brooks that flow through the sands of Cape Cod, several of those on its southern slope being famous for their sea-trout fishing. These, however, lie outside our present province and at present only a couple of small streams on the Massachusetts Bay side of the cape still support a race of trout that run down to the sea. Sea trout seem to be unknown between Cape Cod and Cape Elizabeth, unless possibly in one or two streams tributary to Ipswich Bay. Without a local knowledge more intimate than we boast we can not say how generally sea trout may now exist in the streams in eastern Maine, but according to Evermann (1905a, p. 105) trout inhabit the tidal portions of many of the brooks that empty into Casco Bay. Huntsman found no definite evidence of trout in salt or brackish water on the New Brunswick side of the Bay of Fundy, but local inquiry has elicited the information that there are fish of this habit in a few streams—notably in Salmon River—on the north and west coasts of Nova Scotia, where in the past many streams formerly held sea trout but have long since been fished out.

Anatomically and specifically the "sea trout" is indistinguishable from the ordinary brook trout;[54] they are simply fish that have the habit of running down to salt water, and even in streams free of access to the sea, cold enough throughout their lengths, and harboring these "salters" (as they are called on Cape Cod), most of the trout never leave fresh water. All who have given special attention to our sea trout are agreed on this. It is still an open question whether the habit is hereditary or whether it is acquired independently by each individual fish. Personally, we incline to the first view, chiefly because sea trout are slow in reestablishing themselves in any stream once they are brought to a low ebb by hard fishing.

[54] There is another species of sea trout in northern Canadian waters, very plentiful along the coast of northern Labrador.

The trout that follow this habit grow so much more rapidly on the abundant rations the salt estuaries provide than do most of their relatives that remain in the brook that sea fish run up to from 1 to 3 pounds in weight in streams where the fresh-water trout seldom exceed half a pound.

On Cape Cod the sea trout go down to salt water in November immediately after spawning, winter there, and begin to run in again in April, all being once more in brackish or fresh water by mid-May. In the Nova Scotian streams tributary to the Bay of Fundy it is said that they do not appear until later in spring (we can not vouch for this). While in salt water—at least along Cape Cod—the trout feed chiefly on shrimps, mummichogs (Fundulus), and other small fish. Trout never stray far from the stream mouths in the Gulf. So close, indeed, do they hang that we have never head of the capture of a single one outside the tidal creek or estuary into which its home stream empties. Hence trout have no place [55] in the fish fauna of the open Gulf.

THE SMELTS. FAMILY ARGENTINIDÆ

The smelts are small salmons in all essential respects, except that the stomach is simply a sac with few or no pyloric cœca, whereas in their larger relatives of the salmon family there are large numbers of such cœca. However, it is not necessary to look so deeply among the few species proper to the Gulf to tell if a fish be smelt or very young salmon, for the former all have pointed noses and are of slender form, whereas the young of our three salt-water salmons—humpback, Atlantic, and sea trout—are stouter bodied with rounded noses. In most cases, too, the shape of the tail alone would suffice to separate smelt from salmon smolt, for in the latter it is never as deeply forked as in the former, though considerably emarginate instead of square as in the adult salmon.

Three smelt fishes occur in the Gulf of Maine—the smelt (very common), capelin (a sporadic visitor from the north), and argentine (rare, but perhaps occurring more regularly than actual recorded captures suggest).

KEY TO GULF OF MAINE SMELTS

1. Dorsal fin situated far behind pectorals 2
   Dorsal fin originates over the tip of pectorals ..... Argentine, p. 147
2. Upper jaw almost as long as lower; teeth large; there is a group of strong fangs on the tongue; pectoral fins have 12 rays or fewer ..... Smelt, p. 143
   Lower jaw much longer than upper; teeth so small as hardly to be visible; no fangs on tongue; pectoral fins have 15 to 20 rays ..... Capelin, p. 140

49. **Capelin** (*Mallotus villosus* Müller)

Jordan and Evermann, 1896–1900, p. 520.

Description.—The capelin is an even slenderer fish than the smelt, its body being only about one-seventh to one-eighth as deep and about one-twelfth as thick as long, except in the case of females with the abdomen distended with spawn; it is of nearly uniform depth from gill cover to anal fin, whereas the smelt is usually deepest about its mid length (at least if the fish is fat), which gives the two species

[55] Trout are occasionally taken about Woods Hole in the nets in winter.

characteristically different aspects. The head of the capelin is pointed like that of the smelt, the mouth gaping back to below the center of the very large eye with the tip of the lower jaw projecting noticeably beyond the upper. The scales are minute—much smaller than those of the smelt and more numerous (about 200 per row on the sides of the body)—its teeth so small as to be hardly visible to the naked eye, and the tongue fangs, so characterisitc of the smelt (p. 144), are lacking here. The outline of the adipose fin likewise helps separate capelin from smelt, for in the former it is low and about half as long as the anal, while in the latter it is short and high. The pectoral of the capelin is likewise broader, with 15 or more rays.

The capelin exhibits a pronounced sexual dimorphism, males having much the longer pectoral fins, and the base of the anal is elevated on a pronounced hump, whereas it follows the general outline of the belly in the female. In the males, too, a longitudinal row of scales immediately above the lateral line and another along each side of the belly are not only pointed and distinctly larger than the other

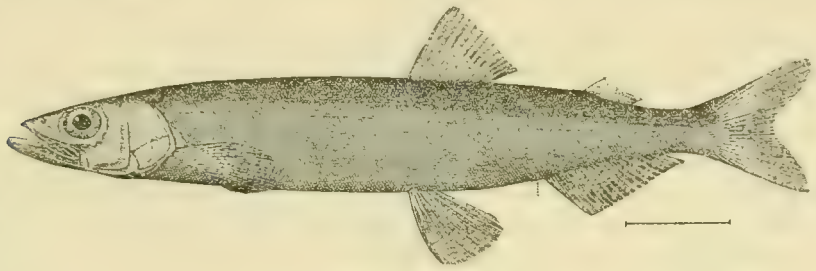

FIG. 55.—Adult

FIG. 56.—Larva, 23 millimeters. After Schmidt

CAPELIN (*Mallotus villosus*)

scales but become very elongate at spawning time, forming four ridges very evident when the fish is taken in the hand.

Color.—The capelin, like the smelt, is transparent olive to bottle green above, but its sides are uniformly silvery below the lateral line and the scales are dotted at the margins with minute dusky specks (in the smelt there is a distinct silvery band on each side); the belly is white and at spawning time back and head darken.

Size.—Capelin are seldom more than 6½ to 7½ inches long.

General range.—Boreal—Arctic seas, south to the coast of Maine [56] on the Atlantic coast of America.

Occurrence in the Gulf of Maine.—The capelin is a sub-Arctic fish that occurs at irregular intervals in the Gulf of Maine, chiefly on its eastern side, as might be expected of a visitor from the north.

[56] According to Jordan and Evermann the capelin finds its southern limit at Cape Cod, but we find no actual records of its occurrence farther south than here mentioned.

"The capelin (*Mallotus villosus*)", writes Doctor Huntsman,[57] "is endemic around Newfoundland and in the Gulf of St. Lawrence. In the latter region, at least, it occurs abundantly only in limited areas, which shift somewhat from year to year. It occurs periodically in similar limited areas farther south. The southeastern corner of Cape Breton is the center of such an area, where large quantities were taken in 1917. Halifax is the center of another area, where, however, it is more rare. In 1916 it was abundant at Sambro, near Halifax. The next area is in the Bay of Fundy, where they have, exceptionally, been taken in large quantities at long intervals."

Apparently a period of this sort occurred about the middle of the past century, for Perley, writing in 1852, reported it from a number of points in the neighborhood of St. John, New Brunswick. It seems then to have disappeared and for many years thereafter was unknown anywhere in the Gulf of Maine, but it reappeared in the Bay of Fundy in May, 1903, when it was common, and a few were again taken off Passamaquoddy Bay in that same month of 1915.[58] This was the prelude to a period of local abundance, for capelin were noticed among the herring taken in the weirs of the Passamaquoddy Bay region in October, 1916, becoming so plentiful by the end of November that one catch of 3,000 pounds of fish consisted of 2,000 pounds of capelin and only 1,000 of herring. They were also reported at various localities along the New Brunswick coast at that time. Probably they persisted locally in the Bay of Fundy throughout the winter of 1916–17, for in the following May and June large numbers of capelin appeared in Minas Basin. We find no record of capelin within the limits of the bay in 1918, but not only were they taken again in 50 fathoms of water off Passamaquoddy Bay in January, February, and March, 1919, but they appeared with smelts a month later as far west as the Penobscot River, penetrating far inland. Since then none have been seen in the Gulf of Maine.

In spite of the fact that the capelin no doubt invades the Gulf from the east, it is unknown along the western shores of Nova Scotia between Cape Sable and the mouth of the Bay of Fundy. Evidently it travels directly north until caught up in the cul-de-sac of the bay on the rare occasions when it rounds the cape, which is in line with other evidence to the effect that, once past Cape Sable, the general entrant track of visitors from the north lies some distance off the Nova Scotian coast.

Habits.—Although the capelin is not regularly endemic as far south as the Gulf of Maine it may breed locally in the Bay of Fundy on the rare occasions when it persists there for more than one year. It spawns in salt water (unlike its close relative the smelt, which is anadromous), depositing its eggs on sandy bottom along shore from just below tide mark down to 35 or 40 fathoms, where they stick together in clusters like herring eggs. Many accounts have appeared of the multitudes of capelin that gather along northern coasts at this time.

[57] Quoted from a letter.

[58] Huntsman (1922a, p. 12) and Kendall (1917, pp. 28–30, and 1919, pp. 70–71) give details.

In north European seas capelin spawn from April until July; we have found them spawning along the coast of Labrador in multitudes in July in 1900. Probably April and May would cover such spawning as occurs in the Bay of Fundy. The spawning act has been described variously. According to Lanman (1874, p. 225) each female is accompanied by two males that crowd her between them. The eggs are reddish and about 1 mm. in diameter, while the larvæ are about 7 mm. long at hatching. Larvæ only 8 mm. in length have entirely absorbed the yolk, the rudiments of the dorsal and anal fins are visible at 14 mm., while at 23 mm. the adipose fin can be distinguished, the fin rays are formed, and the little capelin is easily recognizable as such.

The capelin so seldom appears in the Gulf of Maine that we need state of its habits merely that, unlike the smelt, it is a fish of the high seas frequently encountered far out from land; it never enters fresh water; comes inshore only to spawn and then as a rule moves out again; travels in vast schools at spawning time,

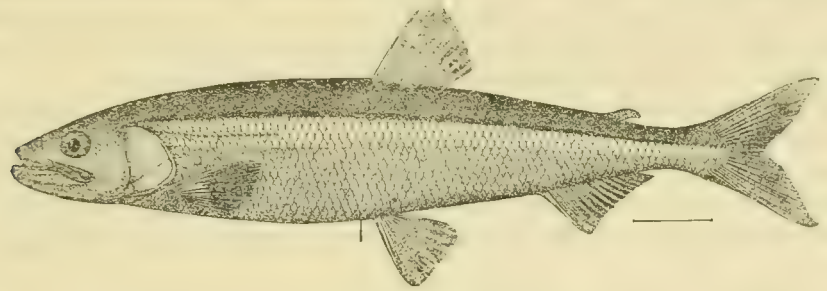

FIG. 57.—Adult

FIG. 58.—Fry, 26 millimeters

SMELT (*Osmerus mordax*)

when it often strands on the beach in countless multitudes; and that it is the chief bait fish of Arctic seas, preyed upon by whales and every predaceous fish, particularly by cod. Capelin themselves feed chiefly on small crustaceans, particularly copepods, euphausiid shrimps, and amphipods. It is also known to devour its own eggs. We can bear witness that it is a delicious little fish on the table.

60. **Smelt** (*Osmerus mordax* Mitchill)

SALT-WATER SMELT; ICEFISH

Jordan and Evermann, 1896–1900, p. 523.

Description.—The smelt is distinguishable from all other fish common in our waters by its slender form, long pointed head, the presence of a small but evident

adipose fin standing above the rear part of the anal, and a deeply forked tail. The capelin and argentine alone among the Gulf of Maine fishes share this combination of characters with the smelt, but the latter is distinguishable from the argentine at a glance by the location of its dorsal fin above instead of in front of the ventrals and by its larger mouth, while the large, fanglike teeth of the smelt's tongue, its larger scales (of which there are about 75 rows on the sides, all alike in the two sexes), its shorter adipose fin, its narrower pectoral fin, and the facts that its lower jaw projects but slighlty beyond the upper and that its scales slip off very easily, obviate all danger of confusing it with the capelin. The body of the smelt is only about one-fifth as deep as long (exclusive of caudal fin), with broadly rounded back but compressed enough to be egg-shaped in cross section. It is deepest about its mid length, tapering thence toward the head as toward the tail (at least in fat fish), whereas the capelin is of nearly uniform depth from gill opening to anal fin (p. 140). Its mouth gapes back of the eye.

Printed accounts of the smelt usually credit it with a peculiar "cucumber" odor, and smelt fishermen often speak of a trace of this, but it is so faint that I have never noticed it though I have caught and handled many.[59]

Color.—Transparent olive to bottle green above, the sides a paler cast of the same hue but each with a broad longitudinal silvery band. The belly is silvery, while the fins and body are more or less flecked with tiny dusky dots. This color pattern is shared by another slender little fish, the silverside (Menidia, p. 179), but as the latter has two large dorsal fins there is no danger of confusing the smelt with it.

Size.—Smelt grow to a maximum length of about 13 or 14 inches. Few larger than a foot long are seen, however, and adults run only about 7 to 9 inches. According to size and fatness smelt weigh from 1 to 6 ounces.

General range.—East coast of North America from eastern Labrador and the Gulf of St. Lawrence southward regularly to New Jersey, and reported to Virginia, running up into streams and rivers to spawn.

Occurrence in the Gulf of Maine.—The smelt is a familiar little fish around the entire coast line of the Gulf of Maine, but varies greatly in abundance from place to place according to the accessibility of streams suitable for spawning, from which it seldom wanders far alongshore. Smelt are still very abundant all around the inner parts of Massachusetts Bay and its tributary harbors, though many of the local streams are barred to them now; thence northward and eastward, too, along the coast of Maine, as illustrated by the following report of commercial catches from the several coast counties of that State in 1919:

County	Number of pounds	County	Number of pounds
York	8,000	Knox	71,100
Cumberland	136,202	Waldo	41,800
Sagadahoc	74,230	Hancock	94,835
Lincoln	53,500	Washington	17,850

[59] The European smelt (*O. eperlanus*) smells so strong that it is not held in very high esteem.

Smelt are also found very generally along both the New Brunswick and the Nova Scotian shores of the Bay of Fundy, but to judge from Canadian fishery statistics they are far more plentiful near the mouth of the bay and on the Nova Scotian side than anywhere on the New Brunswick shore [60] or farther up the bay, where only a few hundred pounds are caught annually. Smelts are also plentiful on the west coast of Nova Scotia, facing the open Gulf, as is reflected in a catch of almost 58,000 pounds for Yarmouth County in 1916–17.

The adult smelts return to salt water immediately after spawning, to spend the summer either in the estuary into which the stream in which they spawn empties or in the sea close by. On the Massachusetts coast north of Cape Cod all the spent fish have left fresh water by the middle of May, in some years earlier. On the Maine coast, too, a good proportion of the spent fish are in salt water by the first week in May, for we have seen a bushel of large smelt taken in a weir at Cutler (near the mouth of the Grand Manan Channel) as early as May 4.[61]

The summer habitat of the smelt varies off different parts of the coast of the Gulf depending on the summer temperature of the water and perhaps on the food supply. In the Massachusetts Bay region and along the southern coast of Maine most of them desert the harbors and estuaries during the warmest season, probably, however, moving out only far enough to find cool water at a few fathoms depth. A few may be found in harbors through the summer, however. Smelt, for instance, are caught in Cohasset Harbor throughout the summer in some years, but not in others; and east of Penobscot Bay, where the surface temperature does not rise as high as it does off Massachusetts, smelt are to be found in the harbors, bays, and river mouths all summer, when they are sometimes taken in numbers in the weirs. The smelts are always confined to a very narrow zone along shore, for none has ever been reported more than a mile or two from land or at more than a few fathoms depth. Though confined to shoal water, the schools (which are mostly composed of individuals of one size and are probably the product of a single hatching) live pelagically, not on the bottom.

Food.—The smelt is predaceous. Most authorities describe it as feeding on small crustaceans, which is correct so far as it goes for shrimp (decapods) are probably its favorite food and they are certainly the best smelt bait, but small fish also form an important item in its diet. We have, for example, found smelts taken in the Sheepscot River in May packed full of young herring, and have caught many on small mummichogs (Fundulus), while at Woods Hole cunners, anchovies, and alewives have been identified from smelt stomachs.[62] The Woods Hole diet list also includes shellfish, squid, annelid worms (Nereis), and crabs, but even as greedy a fish as the smelt ceases to feed during its spawning visits to fresh water.

Breeding habits.—The adult smelt all gather in harbors and brackish estuaries early in autumn, smelt fishing with hook and line being in full swing by October, and by the time the first ice forms in December some of them have run as far as the head of tide. The smelt winter between the harbor mouths and the brackish

[60] The catch in 1916–17 was 115,000 pounds for Annapolis and Digby Counties, Nova Scotia, while for Charlotte County, New Brunswick, it was only 7,100 pounds.

[61] Atkins (1887) gives much interesting information on the smelt in Maine.

[62] Vinal Edwards's notes.

water farther up—that is, in the same zone as the sea trout (p. 140)—the maturing fish commencing their spawning migration into fresh water as soon as the streams warm to the required degree in spring. Temperature observations by the Massachusetts Commission show that the first smelt appear on the spawning beds in Weir River, a stream emptying into Boston Harbor, when the temperature of the water rises to about 40° to 42°. About Massachusetts Bay this may take place as early as the first or as late as the last week in March, depending on the forwardness of the season and on the particular stream in question. The chief production of eggs is in temperatures of 50° to 57°, and spawning is completed there by about the 10th or 15th of May, year in and year out. East of Portland smelt seldom commence to run before April, to continue through May as just noted. In the colder streams on the southern shores of the Gulf of St. Lawrence they do not spawn until June, but along the southern New England coast south of Cape Cod, on the other hand, they may commence as early as February.

As a rule smelt do not journey far upstream. Many go only a few hundred yards above tidewater, whether the stream be small or large, while some even spawn in slightly brackish water, as in certain ponds back of barrier beaches (e. g., Straits Pond, Cohasset, Mass.), but flooding with salt water, which sometimes happens, kills the eggs.

The eggs average 1.2 mm. (0.05 inch) in diameter and sink to the bottom, where they stick in clusters to pebbles, to each other, or to any stick, root, grass, or water weed they chance to touch. According to the Manual of Fish Culture a female weighing as little as 2 ounces will produce between 40,000 and 50,000 eggs; 70,000 eggs have been taken from a fish 7½ inches long.[63] The eggs of the closely allied European smelt (*Osmerus eperlanus*) hatch in 8 to 27 days, according to temperature. Probably the incubation period of the American fish is the same, for smelt eggs are reported as hatching in 13 days at the Palmer (Mass.) hatchery. There is no reason to suppose that the rate of growth of our smelt differs much from that of the European (that is, to a length of 1¾ to 2¾ inches by the first autumn).

The precise season when young smelt go down to the sea in the Gulf of Maine streams is yet to be learned; probably early in summer.

Most of the smelt evidently do not spawn until they have passed a winter, a summer, and a second winter in salt water.

The smelt has proved a favorable fish for artificial hatching and at present large numbers of fry are so produced yearly in Massachusetts, the eggs being taken in Weir River, just mentioned. It has proved possible to reestablish smelt by introducing the eggs or fry into streams from which it has been extirpated. For example, good smelt fishing was reported in "Poorhouse Brook," Saugus, a tributary of Boston Harbor, three years after the stream was stocked with eggs, and attempts on Long Island have been similarly successful. It is the prevailing opinion that smelt are now increasing in Massachusetts. To maintain the stock is simply a question of providing spawning grounds of sufficient extent or of making up for the lack of such by artificial propagation.

[63] Rice. Report of the Commissioner of Fisheries of Maryland, 1878.

The commercial importance of the smelt, one of our very best fish, is considerable, but from a dollars and cents standpoint its sporting value to the coastwise inhabitants of New England is probably greater, for smelt fishermen flock to the harbors and stream mouths throughout the autumn. For instance, as many as 2,326 people have been counted fishing at one time about Houghs Neck in Boston Harbor alone, and this same sort of thing is to be seen up and down the coast. So plentiful are the fish on occasion and so greedily do they bite, especially on the flood tide, that it is usual to number the catch about Massachusetts Bay by the dozens rather than by the individual fish. Shrimp are the best bait, bloodworms (Nereis) second best, small minnows or clams a poor third, and smelt have also been taken on a small red artificial fly in the Gulf of St. Lawrence.

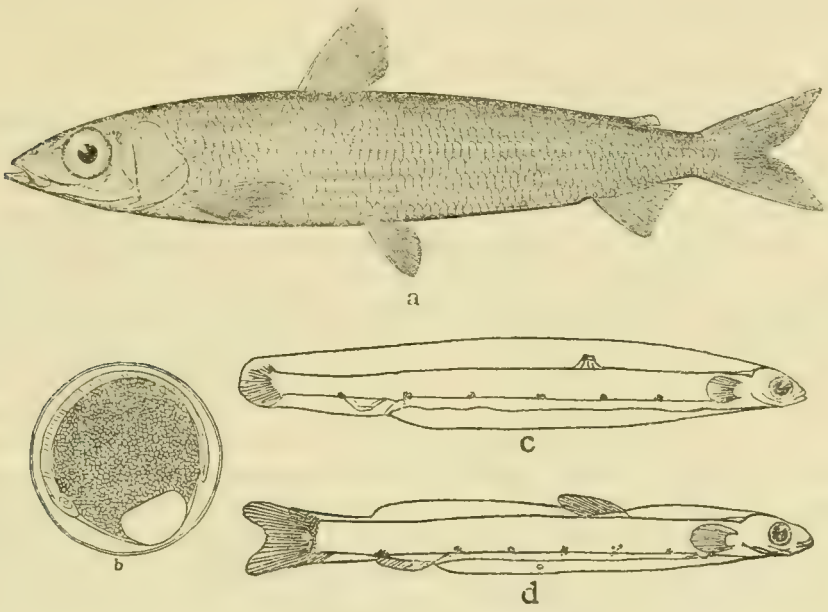

FIG. 59.—Argentine (*Argentina silus*)

a, Adult. *b*, Egg. After Schmidt. *c*, Larva, 28 millimeters. After Schmidt. *d*, Fry, 45 millimeters. After Schmidt.

51. **Argentine** (*Argentina silus* Ascanius)

HERRING SMELT

Jordan and Evermann, 1896–1900, p. 526.

Description.—The argentine is a smeltlike little fish with the pointed nose, deeply forked tail, and slender, compressed body characteristic of the family, but it has much larger eyes—a character no doubt associated with its deep-water home—than either smelt or capelin; its mouth is much smaller, not gaping back even as far as the eye; and its dorsal fin stands wholly in front of the ventrals, instead of above them as in both its near relatives. These characters, together with the presence of an adipose fin above the anal that it shares only with smelt, capelin, the salmon

tribe, and certain oceanic species such as the pearlsides, among common Gulf of Maine fishes, serve to separate it at a glance from any other species likely to be found within the limits of the Gulf.[64]

In the argentine, as in the smelt, the body (about one-fifth as deep as long) tapers toward both head and tail, but its sides are so flat, its back and belly so broadly rounded, that it is nearly rectangular in cross section instead of oval. Its scales, too, are larger than those of the smelt, there being only 60 to 70 rows along the lateral line. The adipose fin is very small and the jaws are toothless, though the palate and tongue are armed with small teeth.

Color.—We have never seen a freshly taken adult, and its color is variously described by different authors. All agree, however, that the back is brownish or olivaceous, the sides silvery or with iridescent golden or brassy luster, and the belly white. The adipose fin is said to be yellow.[65]

Size.—The argentine is a larger fish than the smelt or the capelin, growing to a length of about 18 inches.

General range.—North Atlantic, usually in water as deep as 80 to 300 fathoms, chiefly on the European side where it is known from northern Norway south to the northern part of the North Sea.

Occurrence in the Gulf of Maine.—The argentine has seldom been taken in our waters. Records have been published for Belfast and for Biddeford Pool, Me., and we collected two specimens on the *Grampus*—the first, of 49 mm., taken in the closing net at 35 fathoms, 33 miles south of Mount Desert Rock on August 14, 1912, and the second, of 38 mm., one year later, from an open haul from 85 fathoms near by, which completes the list. Probably it is more common in the deeps of the Gulf than these few captures suggest, for on April 17, 1920, a haul from 200 meters in the southeast corner of the Gulf yielded 43 eggs unmistakably of argentine parentage.

Habits.—Nothing is known of the life of the herring smelt in our Gulf, and little enough is known of it in Scandinavian waters, where it is sometimes caught on deep-set lines baited with herring or mussels, and where, like other deep-sea fishes, it is occasionally swept up to the surface by some upwelling of the water, to drift there helplessly. It certainly begins spawning as early as April in the Gulf of Maine, and judging from European experience it probably continues all summer. Although buoyant, the eggs float in the deeper water layers, seldom rising to the surface. They are among the largest of buoyant eggs (3 to 3.5 mm. in diameter), with flat oil globule (0.95 to 1.16 mm.) and vacuolated yolk. Newly hatched larvæ averaging about 7.5 mm. long have a large yolk sac, but at a length of 12 mm. this has been absorbed and a line of spots has appeared along the belly. The rudiments of the dorsal and anal fins are visible at 28 mm., and by the time the little fish has reached 45 mm. the fin rays are formed, the anus has traveled forward, and the forked outline of the tail is apparent, but it is not until the larva is about 50 mm. long that the ventral fins appear.

[64] There is a second argentine in Scandinavian waters, but it is not known on our side of the Atlantic.

[65] For an excellent account of the argentine see Smitt (Scandinavian Fishes, 1892).

THE LANTERNFISHES. FAMILY MYCTOPHIDÆ

The most diagnostic external characters of the lanternfishes are their large eyes (situated close to the tip of the blunt snout), wide mouths gaping back beyond the eye, one soft-rayed dorsal fin, a deeply forked tail, and the presence of a series of phosphorescent organs as conspicuous pale spots along the sides. Some of them have an adipose fin on the back behind the dorsal fin, but others lack this. When present, this fin is so small and fragile that it is apt to be destroyed by the rough treatment the fish receive in the tow net, in which they are usually taken. Among Gulf of Maine fishes they most nearly resemble the anchovy (p. 124), pearlsides (p. 151), and cyclothone (p. 153); but they are readily distinguished from the first of these by the presence of phosphorescent organs and by the fact that the snout does not project beyond the mouth, from the second by their much wider mouths, and from the third by their much larger eyes.

They are among the commonest fishes on the high seas, where they live at a considerable depth by day but often rise to the surface at night, and a number of them (especially of the genus Myctophum) have been taken along the continental slope abreast of the Gulf of Maine. Hence one species or another may be expected to stray in over the banks if not into the inner parts of the Gulf.

The number and arrangement of the phosphorescent organs offer the readiest means of identification within the family, and should a lanternfish be taken to which the following account does not apply, we refer its captor to Goode and Bean (1896) and to Brauer [66] or, better, suggest that it be submitted to the United States Bureau of Fisheries to be named.

52. **Lanternfish** (*Æthoprora effulgens* Goode and Bean)

Jordan and Evermann, 1896–1900, p. 566.

Description.—This curious little oceanic fish suggests the pearlsides (p. 151) in the presence of an adipose fin and of well-developed phosphorescent organs, but its mouth is much wider (it gapes back of the eye), its eye is even larger and situated close to the end of the nose, and the dorsal profile of its head is very convex. There is a very large and noticeable phosphorescent organ covering the entire tip of the snout, including the margin of the orbit, and extending down over the edge of the upper jaw, to which there is no parallel in the pearlsides or in any fish regularly inhabiting the Gulf of Maine. There are also a number of small phosphorescent spots arranged along the lower sides and on the lower surface as shown in the illustration.[67]

The arrangement of the fins (all of which are soft) is essentially the same as in the pearlsides except that the dorsal (about 15 rays) and anal (about 16 rays) stand relatively farther forward while the pectoral and adipose fins are proportionately smaller and the caudal fin is more deeply forked.

Color.—The color has not been described. Probably it is black or at least of some dark shade, with the phosphorescent organs pale blue or green.

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[66] Die Tiefsee-Fische. Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition, 1898–99 (1906), Band XV, Teil I.

[67] The structures along the lateral line shown in the illustration are large scales, not phosphorescent organs.

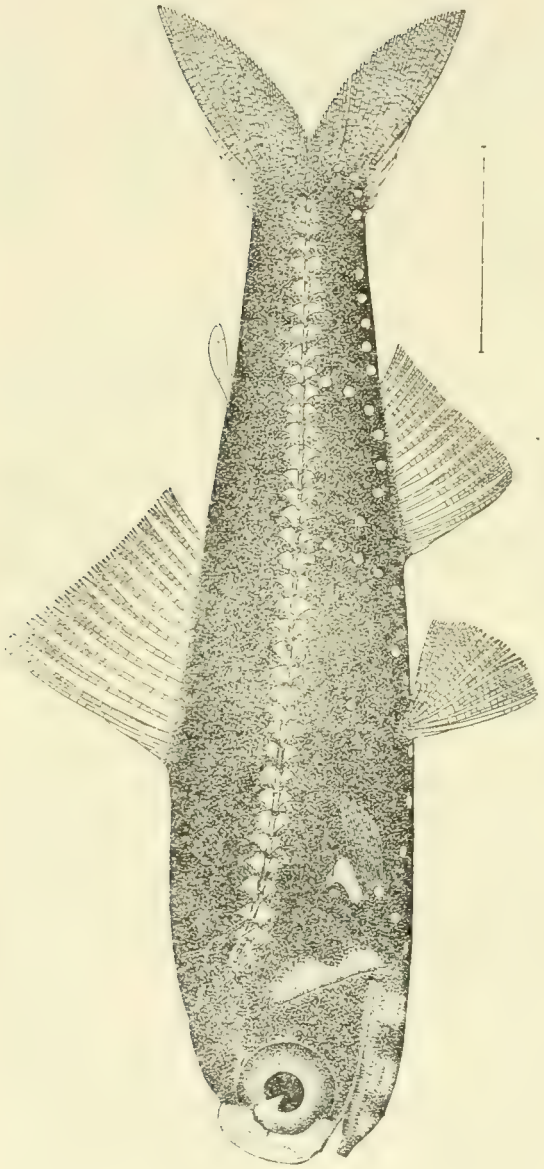

FIG. 60.—Lanternfish (*Ethoprora effulgens*)

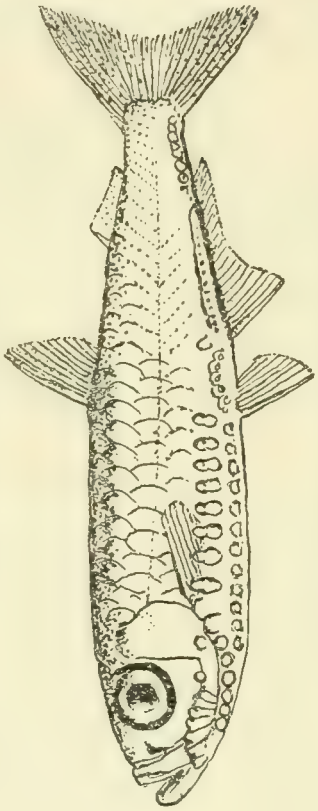

FIG. 61.—Pearlsides (*Maurolicus pennanti*). After Smitt

General range and occurrence in the Gulf of Maine.—This species is undoubtedly oceanic and only a stray within the limits of the Gulf, but one specimen has been found in the stomach of a cod caught on Browns Bank.[68]

FAMILY STOMIATIDÆ [69]

This family includes a large number of soft-rayed oceanic fishes of the mid-depths and of the most diverse appearance, all of them with well developed phosphorescent organs, very large eyes, large mouths, a lower jaw projecting beyond the upper, and with teeth in both jaws. Some have and others lack the adipose fins, but in all of them the ventrals are inserted far back on the abdomen. They differ from the herrings and salmons in the structure of the skull. Only one species, the pearlsides (p. 151), has been recorded more than once or is to be expected except as a stray in the Gulf of Maine, but two others have been taken there casually.

53. **Pearlsides** (*Maurolicus pennanti* Walbaum)

PEARLFISH; LANTERNFISH

Jordan and Evermann, 1896–1900, p. 526.

Description.—The presence of an adipose fin between dorsal and caudal, together with phosphorescent organs, distinguishes the pearlsides (fig. 61, p. 150) from all other fish that occur regularly in the Gulf of Maine. This is a flat-sided, large-headed little fish, its body (about one-fifth as deep as long, excluding caudal fin) deepest forward of the ventral and dorsal fins, its eye very large, its lower jaw projecting, its mouth large but oblique, and both its jaws armed with minute teeth. The dorsal fin (about 11 or 12 rays) stands above the space between ventrals and the anal, which is longer than the dorsal. The adipose fin (both of Woods Hole [70] and of Norwegian [71] examples) is low and long, much as in the capelin.[72] The caudal fin is broad and slightly forked.

The pearlsides has been described as scaleless, but this is not correct, for both Scandinavian and Woods Hole specimens have been found to be clothed with large but extremely thin transparent scales. There is no definite lateral line.

The most interesting and diagnostic feature of the pearlsides is the presence of a series of phosphorescent organs or luminous dots situated as follows: First, 12 pairs along the belly between pectoral and ventral fins, followed by 5 or 6 from ventral to anal, and, after a gap, by 24 or 25 between the center of the anal fin and the base of the caudal fin, all these together forming a practically continuous row on each side of the belly from throat to tail. Second, a row of larger spots slightly higher up on each side, 6 from chin to pectoral fin, 9 thence backward to the ventrals. Third, a group of 6 low down on each side of the cheek and throat; likewise a spot in front of the base of the pectoral and 2 on the chin.[73]

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[68] Reported by Goode and Bean (1896).

[69] We follow Boulenger in including the pearlsides, viperfish, and cyclothone in this one family.

[70] Sumner, Osburn, and Cole, 1913, p. 743.

[71] Smitt, Scandinavian Fishes, 1892, p. 933, pl. 44, fig. 3.

[72] Goode and Bean (1896, p. 96) describe it as "very small," but probably their specimens were battered.

[73] This account is based chiefly on Smitt's description and plate.

Color.—The pearlsides, according to Smitt, is colored much like a herring, with dark bluish or greenish back and lustrous silvery-white sides and belly. The luminous spots are black rimmed, their centers pale blue in life but turning yellow in alcohol, and there is a narrow black band along the base of the anal fin and from there to the base of the caudal, the latter being barred with a similar black band.

Size.—Only 1 to 2½ inches long.

General range.—The pearlsides (there are several other species closely allied to it) ranges widely in the open Atlantic, occurring at times in shoals on the coasts of Norway and in British waters. It is particularly common off the coast of Scotland but has seldom been recorded on the American side of the Atlantic.

Occurrence in the Gulf of Maine.—The known occurrences of the pearlsides in the Gulf are few. Storer (1867) records one found alive on the beach at Nahant, Mass., in December, 1837; another taken from the stomach of a cod at Provincetown; a third picked up alive there in July, 1865 (pictured by Storer on plate 25, figure 5); and five others found on the Provincetown beach soon afterward. The pearlsides has not been reported in the southern part of the Gulf since that time, though recorded from Woods Hole on two occasions, 22 having been found dead on the beach in November, 1906. It has been found twice at Grand Manan, however, while in July, 1914, specimens were picked up on the beach at Campobello Island at the mouth of the Bay of Fundy,[74] and others were taken from the stomach of a pollock caught near by. We suspect that the pearlsides is not as rare in the Gulf of Maine as the paucity of actual records for it there might suggest (in fact, Storer tells us that a Nahant fisherman reported finding them repeatedly in the stomachs of haddock many years ago), but that it keeps out of sight, being an inhabitant of the deeper water layers, as its luminous organs would suggest, and comes to the surface chiefly at night. It can hardly be plentiful or we would have taken it in our deep tow-net hauls.

Habits.—The relatives of the pearlsides are oceanic, living in the mid-depths mostly below 150 fathoms, but the pearlsides itself has so often been found in the stomachs of cod and herring (fish that do not descend to any great depth) that there is no reason to regard it as a "deep-sea" stray, nor has it ever been taken far from land so far as we can learn. It probably spawns in early spring, females with large eggs having been taken in Scottish waters in winter.

54. **Viperfish** (*Chauliodus sloanei* Bloch and Schneider)

Jordan and Evermann, 1896–1900, p. 585.

Description.—The viperfish has an adipose fin and luminous organs like its relative, the pearlsides, but in general appearance it is very different from it and from all other Gulf of Maine fishes. Most obvious of its characteristics is its bulldoglike mouth. The lower jaw is longer than the upper, the latter being armed with four long fangs on each side, while the lower has a series of pointed teeth set far apart, those in front very elongate and all of them so long that they project when the mouth is closed. Furthermore, the snout is so short that the very wide mouth gapes far back of the eye. The body is about seven times as long as deep,

[74] These Fundian records are from Huntsman (1922a, p. 13).

compressed, deepest close behind the head, and tapering thence evenly to the tail. The very short dorsal fin (6 to 7 rays) stands far forward and its first ray is elongate, half as long as the fish when not broken off, as it usually is. The ventrals are about midway from the snout to the base of the tail fin, variously pictured as either larger or smaller than the dorsal. The small anal is close to the caudal, with the adipose fin over it. The body is clothed with large but very thin scales. There are several longitudinal rows of small luminous organs on the ventral surface, running from throat to tail, and several more such spots on the side of the head, while a great number of very tiny unpigmented dots are scattered over the trunk.[75]

Color.—Greenish above; sides with metallic gloss; blackish below.

Size.—One foot long.

Occurrence in the Gulf of Maine.—The only definite Gulf of Maine record is of one specimen found in the stomach of a cod caught on Georges Bank in 1874, but as several have been taken off the continental slope abreast of southern New England [76] in deep water, the viperfish may be expected on the offshore banks as a stray.

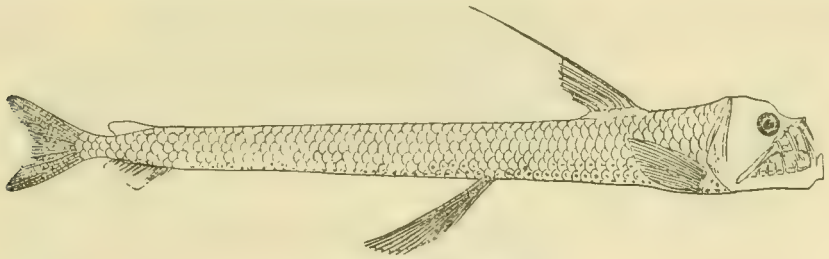

FIG. 62.—Viperfish (*Chauliodus sloanei*)

Habits.—Nothing is known of its habits except that it is an inhabitant of the mid-depths of the Atlantic Basin and probably never rises closer to the surface than 150 or 200 fathoms except, perhaps, during its larval stages. Its teeth suggest a rapacious habit but there is no actual record of its diet nor of its breeding.

55. **Cyclothone** (*Cyclothone signata* Garman)

Garman, 1899, p. 246, pl. J, fig. 3.

Description.—Cyclothone, like the pearlsides and viperfish (pp. 151 and 152), is distinguishable from other Gulf of Maine fishes by the possession of phosphorescent organs. These are arranged as follows: One on the head; 1 close below and in front of the eye; 2 on each gill cover; 9 or 10 between the branchiostegal rays; 2 longitudinal rows on the body, the first containing 13 from throat to ventral fins, 4 from ventrals to anal, and 13 from anal to caudal, while the second is a higher row of 7 reaching about as far back as the ventrals.

The general aspect of the fish is likewise extremely characteristic, the somewhat compressed body being deepest at the gill opening with the upper surface of the head

[75] Die Tiefsee-Fische, by August Brauer. Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition, 1898-1899 (1906), Band XV, Teil I, p. 40.

[76] Goode and Bean (1896, p. 97) list these captures.

concave in profile, the mouth so large that it gapes back of the eye, the lower jaw projecting, the eye very small, and the gill opening very long. The dorsal fin stands over the anal (the latter is much the longer of the two), both originating close behind the middle of the body. The caudal fin is deeply forked and there is no adipose fin.

Color.—Cyclothone signata is colorless or a pale gray, except that the blackish, dark silvery lining of the abdominal cavity shows through, that the phosphorescent organs are black rimmed and silver centered, and that there are the following black markings, viz: A Y-shaped mark on the forehead, a series of spots or short transverse stripes on the flank, spots between the bases of the dorsal and anal fin rays, one or two transverse streaks across the bases of the caudal rays, and a number of irregular flecks and dots along the back and on the gill covers.[77, 78]

General range.—This is an oceanic fish, very abundant in temperate latitudes in the Atlantic where it lives pelagic from about 100 down to about 250 fathoms, hundreds having often been taken in a single haul. It is also known from the Pacific.

Occurrence in the Gulf of Maine.—Cyclothone appears within our limits only as a stray from the Atlantic Basin, one 23 mm. long taken in a haul from 30 fathoms

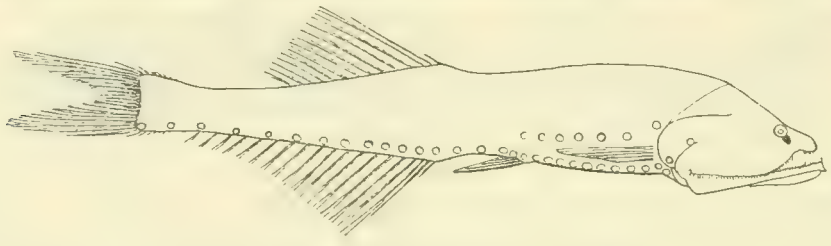

FIG. 63.—Cyclothone (*Cyclothone signata*). After Brauer

on Browns Bank, June 24, 1915, and a second mutilated specimen probably of this species from the Fundy Deep (haul from 90 fathoms), March 22, 1920, being the only definite records.

THE LANCETFISHES. FAMILY ALEPISAURIDÆ

The lancetfishes have a very high dorsal fin and a small adipose fin like that of salmon or smelt, a deeply forked caudal, a short anal, large pointed pectorals and ventrals, and a wide mouth with large teeth. Several species are known, all belonging to deep water, only one of which has been taken within the province covered by this report.

56. **Lancetfish** (*Alepisaurus ferox* Gill)

HANDSAWFISH

Jordan and Evermann, 1896–1900, p. 595.

Description.—The combination of high and long dorsal fin with the presence of an adipose fin of itself marks the lancetfish off from all other Gulf of Maine fishes.

[77, 78] For detailed accounts and colored illustrations see Garman (Memoirs, Museum of Comparative Zoology at Harvard College, Vol. XXIV, 1899, p. 246, plate J, fig. 3. Cambridge), Brauer (Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition, 1898–1899, Band XV, Teil I, 1906, p. 77, Pl. VI, fig. 6), Murray and Hjort (The Depths of the Ocean, 1912, Pl. I. London).

The body is slender, somewhat compressed, deepest at the gill cover and tapering back to a slender caudal peduncle. The snout is long and pointed, the mouth wide, gaping back of the eye, and each jaw has two or three fangs and many smaller teeth. The dorsal fin (41 to 44 rays) originates on the nape and occupies the greater length of the back, is rounded in outline, about twice as high as the fish is deep, and can be depressed in a groove. The adipose fin recalls that of the smelt in form and location. The caudal is very deeply forked and, according to Gunther, its upper lobe is prolonged as a long filament, but if this is a constant feature most specimens so far seen have lost it. The anal fin originates under the last dorsal ray, and is deeply concave in outline. The ventrals are about halfway between the anal and the tip of the snout, while the pectorals are considerably longer than the body is deep and are situated very low down on the sides. There are no scales and the fins are described as exceedingly fragile.

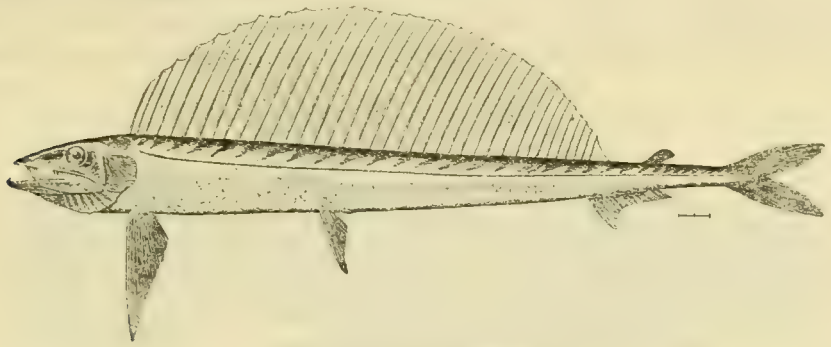

FIG. 64.—Lancetfish (*Alepisaurus ferox*)

Color.—We find no account of its color in life nor have we seen it freshly taken.

Size.—The collection of the Boston Society of Natural History contains a cast of a specimen about 6 feet long taken off Nova Scotia in August, 1910, and this is probably about the maximum size.

General range.—Widely distributed in the deep waters of the Atlantic.

Occurrence in the Gulf of Maine.—A specimen brought in by a fisherman from Georges Bank [79] about 1878 or 1879 is its only claim to mention here. Others have been taken on the deep slopes of LaHave Bank and of the more easterly fishing banks. This is a deep-sea species, only casual above 200 fathoms. Nothing is known of its habits.

THE MUMMICHOGS OR KILLIFISHES. FAMILY PŒCILIDÆ

The mummichogs are small fishes recognizable by the presence of but one short dorsal fin situated far back and by ventrals situated on the abdomen, combined with a small terminal mouth, very thick caudal peduncle, and rounded tail fin. The family is represented by three species in the Gulf of Maine, two of Fundulus and one of Cyprinodon, the former slender and the latter deep in outline, enough difference in body form to distinguish one from the other at a glance.

[79] No information as to this specimen more definite than this is available.

The teeth are likewise different in the two genera, those of Fundulus being sharp-pointed, whereas in Cyprinodon they are wedge-shaped and incisorlike. The two local species of Fundulus are separable by their markings, *majalis* of all ages being barred with black while the adult *heteroclitus* is not.

57. Common mummichog (*Fundulus heteroclitus* Linnæus)

KILLIFISH; SALT-WATER MINNOW; COBBLER; CHUB; MUDFISH; MUD DABBLER

Jordan and Evermann, 1896–1900, p. 641.

Description.—This is a thick-set, stout-bodied fish, about one-fourth as deep as long, its body thickest just back of the head, whence it tapers to the tail. Both its back and its belly are rounded, but the top of the head between the eyes is flat. The snout, as seen from above, is blunt. The mouth is terminal and so small that it does not gape back to the eye. Perhaps the most striking feature of Fundulus is its very deep caudal peduncle and rounded caudal fin. The fins are of moderate

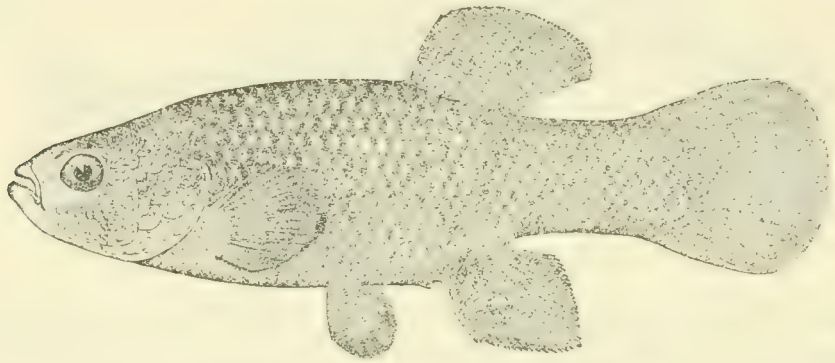

FIG. 65.—Common mummichog (*Fundulus heteroclitus*)

size, the dorsal being situated behind the middle of the body above the anal. The pectorals are broad and rounded. Both head and body are covered with large rounded scales. In males in breeding condition the scales on the sides of the head and on the flanks below and behind the dorsal fin develop fingerlike processes, the so-called "contact organs," on their free edges.

The mummichog exhibits a striking sexual dimorphism in the dorsal and anal fins, which are not only larger in the male than in the female, and the anals of a different shape,[80] but more muscular (they are used as claspers in the act of spawning).

Color.—Males and females differ in color as well as in the sizes of the fins. Out of breeding season the males are dark greenish or steel blue above, marked on the sides with narrow irregular silvery bars or mottlings made up of a series of dots, and with white and yellow spots. The belly is white, pale yellow, or orange; the dorsal, anal, and caudal fins are dark green or dusky with pale mottlings; the front

[80] A detailed account of the sexual differences is given by Newman (Biological Bulletin, Marine Biological Laboratory, Woods Hole, Mass., Vol. XII, No. 5, April, 1907, pp. 314–348).

edges of anals and ventrals are yellow. Sometimes there is a dark-edged, pale-centered eyespot on the rear part of the dorsal fin. At spawning time the pigmentation of the male is generally intensified, the back and upper sides darkening almost to black, while the yellow of the belly becomes more brilliant and the body generally assumes steel-blue reflections. The females (much paler than the males) are uniform olive to bottle green, darker above, lighter below, without definite markings though their sides often show faint and indefinite crossbars of a deeper tone of the same hue. Their fins are much paler than those of males. Very young fry of both sexes show dark transverse bars on the sides but these are lost with growth.

Killifishes, as is well known, vary in shade from very pale to dark, according to the color of their surroundings, and recent experiments [81] have proved that their ability to change from light to dark depends on the sense of sight.

Size.—The maximum length is 5 to 6 inches, but adult mummichogs are seldom more than 3 or 4 inches long in the Gulf of Maine. Several varieties of this species have been described, but they are so closely allied that it is not necessary to discuss them here.

General range.—Coast of North America, from the Gulf of St. Lawrence to Texas.

Occurrence in the Gulf of Maine.—The mummichog is very abundant in suitable locations all around the shores of the Gulf of Maine. However, it seldom if ever ventures into the open sea, for its home is along sheltered sandy beaches, especially where the tide flows over beds of eelgrass or among beds of salt hay (Spartina), among which shoals of "mummies" may often be seen moving in with the flood tide. They also swarm in the tidal creeks that cut up the salt marshes, on the shores of our harbors, and in the brackish water at the mouths of our streams and estuaries, particularly in little muddy pools, creeks, and ditches. So closely, indeed, do they hug the shore that a line drawn 100 yards out from land would probably inclose 90 per cent of all the mummichogs in the Gulf of Maine. Where the shore is bold and rocky, as about the Bay of Fundy, the mummichog is practically restricted to brackish water, and often goes up into fresh water. It is not likely that it ever descends to a depth of more than 2 or 3 fathoms in its journeys in and out of the creeks or up and down the shore. It is so resistant to a lack of oxygen, the presence of carbondioxide, and unfavorable surroundings generally, that it can survive in very foul water.

Habits.—The mummichog winters in a more or less torpid or at least sluggish state on the bottoms of the deep muddy holes or creeks. We have no evidence that it goes to sea during the cold season any more than in summer, and in general it is one of the most stationary of fishes. At ebb tide "mummies" are often trapped in little pools where they remain until the next tide if the water holds, often huddled together in swarms. Should the pool go dry, however, they work their way into the mud for the time being, where we have often found them, and probably they can flop overland for a few yards to some other drain as the striped mummichog does.[82]

[81] Parker and Lanchner. American Journal of Physiology, Vol. LXI, 1922, p. 548.

[82] This habit is described by Mast (Journal of Animal Behavior, vol. 5, No. 5, 1915, p. 341–350).

Food.—"Mummies" are omnivorous, feeding on all sorts of edible things, vegetable as well as animal. They have been found full of diatoms, eelgrass and other vegetable matter, foraminifera, shrimps and other small Crustacea, small mollusks, and even with small fish in their stomachs.[83] At spawning time they greedily eat their own or each other's eggs. They soon congregate about any dead fish or other bit of carrion, to prey either upon it or upon the amphipod scavengers that gather on such dainties.

Breeding habits.—Spawning probably takes place at the same season in the Gulf of Maine as on the southern coast of New England—that is, June, July, and early August. As sexual activity approaches, the males, now brilliantly tinted, court and pursue the females, rivalry among them being very keen, those most highly colored or most excited usually driving off the others. Sometimes they fight fiercely. At the moment of spawning the male clasps the female with his anal and dorsal fins just back of her anal and dorsal, usually forcing her against some stone or against the bottom, the bodies of both being bent into an S and their tails vibrating rapidly while the eggs and the milt are being extruded.[84] Occasionally, however, pairs clasp and spawn free in the water without coming in contact with any object, and sometimes a female is seen to pursue and court a male. They have been seen spawning in a few inches of water, seeking shady spots.

The eggs, which are about 2 mm. in diameter, colorless or pale yellowish and surrounded by a firm capsule, sink and become so sticky on contact with the water that they mass together in clumps or stick fast to sand grains or to anything they chance to rest upon. Incubation occupies from 9 to 18 days, the exact duration probably depending on temperature, this being the factor that governs the rate of development for most fishes. The larva is about 7 to 7.7 mm. long at hatching, its yolk absorbed already, its pectoral and caudal fins fully formed. By the time the little fish has grown to 11 mm. the dorsal and anal fin rays are present in full number, and the first trace of the ventrals is to be seen. At 16 mm. the ventrals are apparent, and fry of 20 mm. resemble the adult not only structurally but in form.

The mummichog is of some little commercial value as bait, but only locally.

58. **Striped mummichog** (*Fundulus majalis* Walbaum)

MUMMICHOG; MUMMY; KILLIFISH

Jordan and Evermann, 1896–1900, p. 637.

Description.—This fish closely resembles the more common mummichog in general form, in its sexual dimorphism, in the form of its dorsal and anal fins, and in the development of "contact organs" on the scales of the breeding male; but it is more slender, its snout is more pointed in side view, its body more definitely fusiform, tapering toward both head and tail, and its caudal peduncle is less stout. The most striking point of difference between the two, however, is to be seen in the color pattern, both sexes of *Fundulus majalis* being definitely barred with black

[83] Lists of stomach contents are given by Field (1907, p. 29).

[84] Newman (Biological Bulletin, Marine Biological Laboratory, Woods Hole, Mass., Vol. XII, No. 5, April, 1907, p. 315) gives an interesting account of the courtship and spawning from which the preceding is condensed.

at maturity as well as when young. In the male the barring is transverse throughout life, the stripes increasing in number from 7 to 10 in the young to from 14 to 20 in adult fish. In the female, however, the original 7 to 10 transverse bars are transformed with growth into two longitudinal stripes on each side, the upper running uninterrupted from gill opening to tail, the lower in two segments, the first from close behind the pectoral to above the ventral, and the second thence backward to just behind the rear edge of the anal fin. Even in the oldest females, however, one or two transverse bars persist on the caudal peduncle.

Color.—Apart from these black bars the male is dark olive green above with silvery sides, a greenish-yellow belly, and a black spot on the rear part of the dorsal fin; his pectorals and caudal pale yellowish—a decidely paler fish than the other "mummy." At breeding time the males become more brilliant, the back turning almost black, the lower sides and belly changing to orange or golden, and the fins to bright yellow. The female is olive green above and white below.

Size.—This is a larger fish than the common mummichog, occasionally growing to a length of 8 inches and frequently to a length of 6 inches.

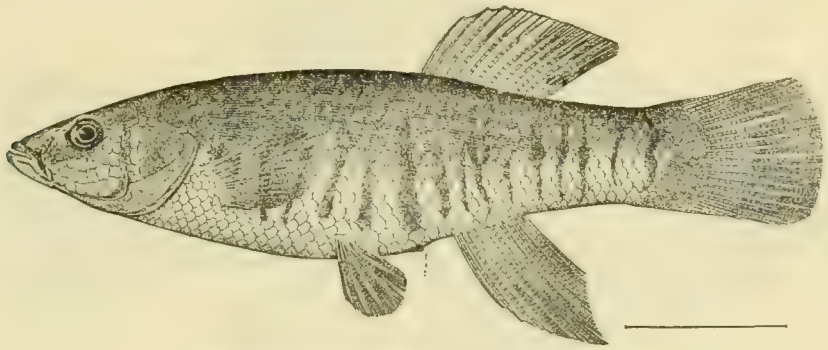

FIG. 66.—Striped mummichog, male (*Fundulus majalis*)

General range.—The coast of the United States from Cape Cod to Florida.

Occurrence in the Gulf of Maine.—We have never seen this fish in the Gulf of Maine, though it is very abundant along the southern shores of New England west of Cape Cod. In fact, the only Gulf of Maine records are for the neighborhood of Boston many years ago. Possibly it is more plentiful along the outer sands of Cape Cod than is now realized; north of that, however, it is only a stray, hence we need merely remark that it parallels *Fundulus heteroclitus* in its confinement to the immediate neighborhood of the land and in its general habits, but that it keeps more strictly to salt water.

59. **Sheepshead minnow** (*Cyprinodon variegatus* Lacépède)

Jordan and Evermann, 1896–1900, p. 671.

Description.—Anatomically, as pointed out above (p. 156), the sheepshead minnow is separated from the mummichogs by the form of its teeth, which are large, wedge shaped, with tricuspid cutting edges, instead of small and pointed. Furthermore, it is so deep bodied (its body nearly half as deep as long, not counting the

tail fin) that it is not apt to be mistaken. It is a stocky little fish more than half as thick as deep, but flat-sided, with high arched back, small flat-topped head, small terminal mouth hardly gaping back to the forward edge of the eye, and with the thick caudal peduncle characteristic of its family. Its tail is square (rounded in the mummichogs), and the fact that almost the whole dorsal fin is in front of the anal instead of over it affords another point of difference. The pectorals are large, reaching back past the base of the ventrals, which by contrast are very small. Both body and head are covered with large rounded scales, largest on top of the head and on the cheeks. Young fish are proportionally more slender than old ones. In this species, as in the mummichogs, the dorsal, ventral, and anal fins are higher in the males than in the females. The male, too, is deeper bodied and averages larger.

Color.—Out of breeding season both males and females are olive above (males rather darker and greener than females) with pale yellow or yellowish-white belly,

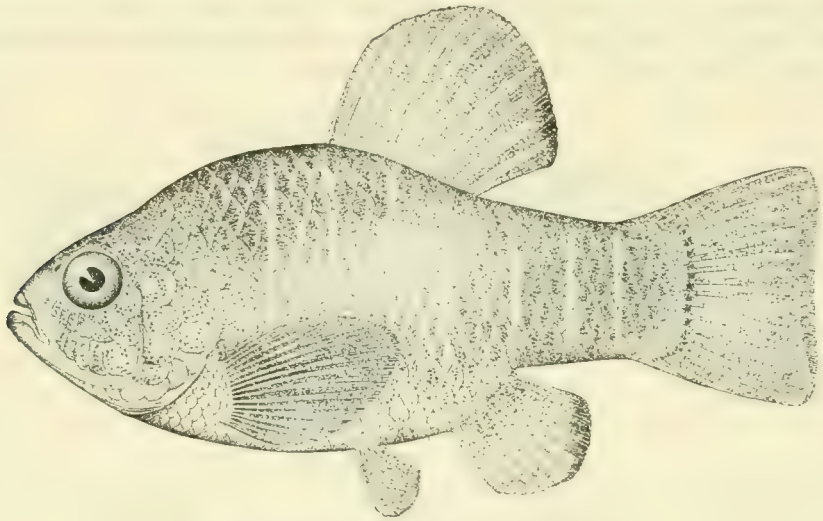

FIG. 67.—Sheepshead minnow (*Cyprinodon variegatus*)

dusky dorsal, and pale orange pectoral, ventral, and anal fins. The young of both sexes are irregularly barred with black transverse stripes, which persist through life in the female but become obscured in adult males. Females, furthermore, have a black spot on the rear corner of the dorsal fin, which is wanting in males, while the caudal fin of the latter sex is marked by two black cross stripes, one at the base and the other at its margin. In breeding season the male assumes a very brilliant coat, his upper parts turning to steel blue in front of the dorsal fin with a greenish luster behind it, while his belly brightens to a deep salmon, his ventrals and anal change to dusky margined with orange, and his dorsal shows an orange margin in front.

Size.—The largest specimens are about 3 inches long.

General range.—Atlantic coast of the United States, Cape Cod to Mexico, in brackish as well as in salt water.

Occurrence in the Gulf of Maine.—This fish, like so many others, finds its northern limit at Cape Cod and would not deserve mention here at all were it not recorded by Storer from the cape. West and south of Cape Cod, however, as at Woods Hole, it is common enough in very shallow water about the heads of bays, along weedy shores, and in brackish water. We have seined many of them with Fundulus at the head of Buzzards Bay.

Habits.—The breeding habits recall those of the "mummy" (p. 158), the males fighting fiercely among themselves and clasping the females just forward of the tail with dorsal and anal fins, while the eggs and milt are extruded. Spawning takes place in shallow water from April to September, the eggs maturing a few at a time, so that any given female spawns at intervals throughout the season. The eggs sink and stick together in clumps by numerous threads. They are 1.2 to 1.4 mm. in diameter, with one large and many minute oil globules. Incubation occupies 5 or 6 days, and even at hatching the larvæ (4 mm. long) show alternate light and dark crossbands. At a length of 9 mm. all the fins are formed, and at 12 mm. the fry show most of the characters diagnostic of the species.[85]

THE BILLFISHES. FAMILY BELONIDÆ

The most noticeable feature of the billfishes is that both jaws are prolonged to form a long slim beak well armed with teeth. Their bodies are very slender, with the anal, dorsal, and ventral fins set far back. There are no finlets, the absence of these being the readiest field mark to separate the billfish from the needlefish (Scomberesox, p. 164). They are swift-swimming, predaceous fishes, represented by many species, most of them American. Only one has ever been recorded in the Gulf of Maine.

60. Silver gar (*Tylosurus marinus* Walbaum)

BILLFISH; SALT-WATER GAR; GARFISH; SEA PIKE; AND VARIOUS OTHER LOCAL NAMES

Jordan and Evermann, 1896–1900, p. 714.

Description.—Several genera of fish with very long jaws or "bills" have been recorded in the Gulf of Maine, the silver gar being distinguishable among them by the fact that both its jaws are elongated instead of only the lower as in the halfbeaks (p. 163), and that there are no finlets between the dorsal and anal fins and the caudal, whereas in the needlefish (Scomberesox, p. 164) there are five or six small dorsal finlets and as many anal finlets. The long bills and slender bodies give the gars a general aspect so peculiar that they are not likely to be confused with any Gulf of Maine fish other than the two just mentioned.

The body of the silver gar is about five and one-half times as long as deep, rounded (not laterally flattened) in cross section, and thicker than deep. Its upper jaw from the eye forward is twice as long as the rest of the head, both its jaws are armed with sharp teeth, and its eye is large. Both its body and the sides of its

[85] An account of courtship and spawning is given by Newman (Biological Bulletin, Marine Biological Laboratory, Woods Hole, Mass., Vol. XII, No. 5, April, 1907, p. 336) and of development by Kuntz (Bulletin, United States Bureau of Fisheries, Vol. XXXIV, 1914 (1916), p. 409).

head are scaly. The dorsal and anal fins are similar in outline, the anterior rays of both being much longer than those toward the rear. Both fins, too, are situated far back, the dorsal originating slightly behind the forward edge of the anal. The ventrals stand halfway between the eye and the base of the caudal. The latter fin is only slightly emarginate, this fact being the readiest field mark to separate this gar from the only other species of its genus (*Tylosurus acus*) so far actually taken near Gulf of Maine limits, for the tail of the latter is deeply forked. There is a distinct ridge or low keel on either side of the caudal peduncle.[86]

Color.—Greenish, darker above, with silvery sides, dull olive fins, and a dark bar on the gill cover. Scales and bones green.

Size.—The silver gar grows to a length of 4 feet.

General range.—Maine to Texas; very abundant on the south Atlantic and Gulf coasts of the United States, often running up fresh rivers above tide water.

FIG. 68.—Silver gar (*Tylosurus marinus*). After Storer

Occurrence in the Gulf of Maine.—The silver gar is common enough along the southern shores of New England, e. g., at Woods Hole and in Rhode Island waters, where it is to be found from June to October. Like many other southern fishes, however, it seldom journeys eastward past Cape Cod, the only definite records of it in the Gulf of Maine being of several specimens collected by Dr. William C. Kendall at Wolfsneck, Freeport, and Casco Bay, Me., and at Monomoy Island, the southern elbow of Cape Cod. We have not met it within the limits of the Gulf of Maine, nor have we heard even a rumor of its presence there from fishermen, pretty good evidence that it is as rare a straggler as the few records indicate, for large silver gars are not fish to be overlooked. With so little claim to mention here, we need merely note that it is very voracious, feeding on all sorts of smaller fishes, and that it runs inshore, possibly even into river mouths, to spawn. The eggs, described by Ryder,[87] are about 3.6 mm. (one-seventh of an inch) in diameter, and stick together and to any object they may touch, by long threads scattered over their surface.[88]

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[86] There are many other species of gars in tropical seas, any one of which *might* stray northward with the Gulf Stream and so to the Gulf of Maine. The silver gar is identifiable among them all by the following combination of characters (no one character alone marks it out among its relatives): Mouth capable of being nearly closed; caudal peduncle with keels; dorsal and anal fins short, the former 15-rayed, the latter 17-rayed; eyes at least one-third as broad as the post orbital part of head is long; body not excessively slender but at least one-fifth to one-sixth as deep as head (including jaws) is long. Jordan and Evermann (1896–1900, p. 709) give a useful key to the species of the family.

[87] Bulletin, United States Fish Commission, Vol. I, 1881 (1882) p. 283.

[88] The closely allied houndfish (*Tylosurus acus* Lacépède) has been taken at Nantucket, but has not been found within the Gulf of Maine. However, since it is not unlikely to appear there as a stray from the south we may point out that it is easily distinguished from the silver gar, which it resembles in general appearance, by its deeply forked instead of only slightly emarginate tail and by the fact that its dorsal and anal fins are much longer, the former with 23, the latter with 21 rays. The following characters in combination will serve to identify it among the several tropical gars: Mouth nearly closable and upper jaw not arched; long dorsal and anal fins; beak at least twice as long as rest of head; greatest depth of body not more than two-thirds the length of pectoral fin; no lateral stripe.

THE HALFBEAKS. FAMILY HEMIRAMPHIDÆ

The halfbeaks are close allies of the billfish (Belonidæ, p. 161), but in the only species of present concern the lower jaw is greatly elongate while the upper jaw is short. They are herbivorous, feeding mainly on green algæ, not carnivorous like their relatives. There are many species in warm seas, only one of which is known to reach the Gulf of Maine.

61. **Halfbeak** (*Hyporhamphus roberti* Cuvier and Valenciennes)

SKIPJACK

Jordan and Evermann, 1896–1900, p. 721.

Description.—The most striking feature of the halfbeak, one which is enough of itself to mark it off from every other fish known from the Gulf of Maine, is the fact that while the lower jaw is as long as in the silver gars, the upper is very short.[89] This is a slender fish, its body being only one-eighth as deep as long, tapering slightly toward head and tail. As in the silver gar, its dorsal (14 to 16 rays) and anal (15 to 17 rays) fins are situated far back, about equal in length and similar in outline, the former over the latter, without finlets. The ventrals stand about midway

FIG. 69.—Halfbeak (*Hyporhamphus roberti*)

between the eye and the base of the caudal. The teeth are small and the scales largest on the upper surface of the head. In young fish the beak is much shorter than it is in adults.

Color.—Translucent bottle green with silvery tinge above, each side with a narrow but well-defined silvery band running from pectoral to caudal fin, the sides darkest above and paler below. The tip of the lower jaw is crimson in life, with a short filament, and three narrow dark streaks run along the middle of the back. The anterior parts of dorsal and anal and the tips of caudal fins are dusky. The belly lining is black.

Size.—Adults are seldom more than 1 foot long.

General range.—Tropical and subtropical on both coasts of America and in the Gulf of Mexico; not uncommon northward to Cape Cod, and straying to the coast of Maine. Abundant off the South Atlantic States.

Occurrence in the Gulf of Maine.—In our cool boreal waters the halfbeak is only a rare stray from the south, so far recorded only twice in the Gulf of Maine—that is, from Machias and from Casco Bay, Me.

[89] Should a halfbeak be taken in the Gulf of Maine it would be well to consult Jordan and Evermann, for there are several other species that *might* reach there as strays, either via the Gulf Stream route or from offshore. One, indeed (*Euleptorhamphus velox*), has been taken at Nantucket. Its lower jaw is even longer and more slender than that of the halfbeak, its body is more compressed, and its pectoral fins are longer.

THE NEEDLEFISHES. FAMILY SCOMBERESOCIDÆ

In the needlefishes, as with the billfishes (p. 161), both jaws (of the adult) are elongated to form a slender beak, and the anal, dorsal, and ventral fins are set far back, but the presence of several finlets between the dorsal and anal fins and the caudal in the needlefishes, which the billfishes lack, is a ready field mark for their identification. Furthermore, their teeth are small and weak, and their bodies only moderately elongate. Only four or five species are known in warm seas, one of which is not uncommon in the Gulf of Maine.

62. **Needlefish** (*Scomberesox saurus* Walbaum)

BILLFISH; SAURY; SKIPPER

Jordan and Evermann, 1896–1900, p. 725.

Description.—The needlefish resembles the silver gar in its slender form and in the fact that both its upper and lower jaws are elongate, but differs from it in the presence of a series of five or six little separate finlets in the spaces between

FIG. 70.—Adult needlefish (*Scomberesox saurus*)

FIG. 71.—Needlefish fry (*Scomberesox saurus*), about 2½ inches long. After Murray and Hjort

the dorsal and anal fins and the caudal fin. The body is about nine times as long (not counting caudal fin) as deep, compressed, tapering toward the head and tail, with slender caudal peduncle, and all the fins are small. The dorsal originates slightly behind the origin of the anal, these two fins being similar in outline and standing far back. The ventrals are situated about midway the length of the body. The caudal is deeply forked and symmetrical, much like the tail of a mackerel. The trunk and a patch on each gill cover are covered with small scales. The lower jaw projects beyond the upper; the teeth are pointed but very small.

Color.—Olive green above with a silver band on each side at the level of the eye and about as broad as the latter. There is a dark green spot above the base of the pectoral; the dorsal fin is greenish; the lower parts silvery with golden gloss. In young fry, which live in the surface waters of the open Atlantic, the back is dark blue and the sides silvery.

Size.—Up to 18 inches long. Those caught on Cape Cod run a foot and more in length.

General range.—Temperate parts of the Atlantic, Pacific, and Indian Oceans, known in the open sea as far north as northern Norway off the European coast, and to northern Nova Scotia[90] and the Banks of Newfoundland off the eastern American coast.

Occurrence in the Gulf of Maine.—While a straggler to our Gulf from warmer waters offshore or farther south, the needlefish has been taken more often on the northern coasts of New England than have any of its relatives, specifically on Cape Cod, at Provincetown, at several locations in Massachusetts Bay, at Annisquam a few miles north of Cape Ann, at Old Orchard (Maine), in Casco Bay, at Monhegan Island, and among the islands at the northern entrance to the Bay of Fundy, but we find no record of it along the Nova Scotian shore of the Gulf of Maine. Apparently the inner curve of Cape Cod from Provincetown to Wellfleet is a regular center of abundance for it, as Storer long ago remarked, for schools of billfish are picked up in the traps along that stretch of beach almost every year, the catch rarely amounting to hundreds of barrels, while hosts of them have been known to strand there. Its numbers fluctuate greatly from year to year, however, and it often fails to appear.[91]

As a rule either many or none at all are caught, their appearance being so sporadic that they can not be looked upon as regular summer residents. They are taken any time from mid-June to October or November, the largest catches usually being made late in summer.[92] Curiously enough, although skippers are often so plentiful in that particular locality they are so rare farther within Massachusetts Bay that many fishermen from Plymouth to Cape Ann had never heard of them, although others had. Certainly we never saw nor heard even a rumor of the fish in many summers spent at Cohasset, and so far as we have been able to learn it is only a stray in the Gulf of Maine north of Cape Ann. It would not be surprising, however, to encounter a large school anywhere within its limits, for at Woods Hole, where the billfish is ordinarily very rare, it has been taken in large numbers on two occasions (1905 and 1906). Witness, too, its occasional abundance off northern Nova Scotia.[90] When it does invade the waters of the Gulf of Maine, it may be expected in multitudes, for it usually travels in vast schools. Day,[93] for example, mentions the capture of 100,000 in a single haul in British waters.

Habits.—The skipper is strictly pelagic. So far as known it lives exclusively at the surface, so much so that in English waters, where it is plentiful in summer, few are caught in nets set as deep as a fathom or two. Its hordes are preyed upon by porpoises and all the larger predaceous fishes; cod and pollock, for instance, feed greedily upon them, as do bluefish. When they strand on the beaches, as often happens, it is probably in flight from their enemies. At sea they attempt to escape by leaping, whole companies of them breaking the surface together as has often been described.

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[90] Cornish (Contributions to Canadian Biology, 1902-1905 (1907), p. 83) states that large schools can often be seen at Canso skipping over the water as they flee from the pollock.

[91] Blake (American Naturalist, Vol. IV, Nov., 1870, p. 521) remarked that while years before he saw thousands stranded at Provincetown not one was seen in 1870. It failed in 1921, also, and no doubt in many intervening years.

[92] For recent information on the local abundance of billfish on Cape Cod we are indebted to Capt. L. B. Goodspeed, a fisherman of long experience and close observation.

[93] The fishes of Great Britain and Ireland, Vol. I, 1880–1884. London.

It is not likely that it ever spawns in the cool waters of the Gulf of Maine, for we have never taken its fry in our tow nets, although they are among the most numerous of young fish in the open Atlantic between the latitudes of 11° or 12° and 40°N. It certainly spawns in the open sea, probably at the surface. Although its eggs have been described as covered with filaments like those of the silver gars,[94] they are not adhesive like the latter, but pelagic. The most interesting phase in the development of the skipper is that the jaws do not commence to elongate until the fry have attained a length of about 40 mm., and that the lower outstrips the upper at first, so that fry of 100 to 150 mm. look more like halfbeaks (Hemiramphus stage) than like their own parents.

Food.—European students tell us that the skipper feeds on the smaller pelagic Crustacea and probably also on small fish, for it is sometimes caught on hook and line. One examined by Doctor Linton at Woods Hole contained chiefly annelids, fragments of fish and vegetable débris, a few copepods, and crustacean larvæ.

Commercial importance.—The needlefish is not of much commercial importance, being too sporadic in its appearances. However, when large catches are made on Cape Cod they find ready sale to the local Portuguese population. If too many are caught for the local trade to absorb, they are sent to Boston, where they are sold for bait.

THE STICKLEBACKS. FAMILY GASTEROSTEIDÆ

Sticklebacks are rather small fish, easily recognizable by the presence of three or more stout free spines on the back in front of the dorsal fin—spines that they can erect or depress at will—and by the fact that each ventral fin is represented by an even larger spine with but one or two rudimentary rays. Bony plates may or may not be developed in the scaleless skin. The Gulf of Maine species may be named by the following key:

KEY TO GULF OF MAINE STICKLEBACKS

1.	Not more than five large dorsal spines	2
	Seven or more dorsal spines	Nine-spined stickleback, p. 166
2.	No bony plates on the upper sides, but there is a bony ridge on either side of the abdomen	Four-spined stickleback, p. 171
	The upper sides are armed with bony plates, and there is a plate in the midline of the belly, but there are no ridges on the sides of the abdomen	3
3.	Many (28 or more) plates on each side	Three-spined stickleback, p. 168
	Only 5 or 6 plates on a side	Two-spined stickleback, p. 171

63. Nine-spined stickleback (*Pungitius pungitius* Linnæus)

Jordan and Evermann, 1896–1900, p. 745.

Description.—The nine-spined stickleback is a slender little fish 5 to 6 times as long (not counting caudal rays) as deep with very slim caudal peduncle, the latter usually with a well-developed keel on either side. Occasionally, however, this keel is very low or wanting. There are no bony plates along the sides of the body,

[94] Skipper eggs were so described by Haeckel (Archiv für Anatomie, Physiologie, und Wissenschaftliche Medecin, herausgegeben von Dr. Johannes Müller, Jahrgang 1855, p. 23, Taf. V, fig. 15. Berlin) 75 years ago. They were not seen again until 1910, when similar eggs, 2.2 mm. in diameter, covered with filaments, were towed in the Atlantic by the *Michael Sars* (Murray and Hjort. The Depths of the Ocean, 1912).

these being present, however, along the bases of the anal and dorsal fins and on the caudal keels. There are no true scales. The most diagnostic character is that there are usually 9 spines on the midline of the back (from 7 to 12 have been counted) in a continuous row from just in front of the pectoral to the dorsal fin, leaning alternately to one side or the other and set in a slightly zigzag line. The spines are slightly curved; wider at the base than at the tip; fairly uniform in size, about one-half to one-third as long as the height of dorsal fin; and each with a small triangular fin membrane at the base. They may be depressed to lie in a shallow mid-dorsal groove. Each ventral fin is represented by a stout curved spine thicker and longer than the dorsal spines. The dorsal and anal fins (the former stands above the latter) are similar in form, tapering from front to rear, the anal preceded by a single stout recurved spine. The tail fin is square-tipped.

Size.—Large adults are seldom more than 3, usually 2 to 2½, inches long.

Color.—Usually dull olive brown above, the upper sides faintly barred or blotched with darker. The belly is silvery, the pubic and thoracic regions often black. The color varies with the season of the year, with the state of sexual maturity, and with the color of the bottom on which it lives, those on dark mud being darker and those on bright sand paler. All become more brilliant during the breeding season when reddish tints appear under the head, the belly turns greenish,

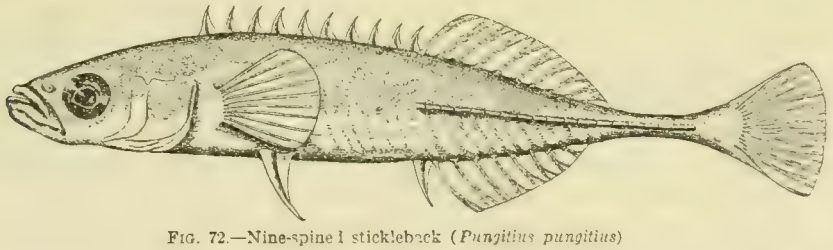

FIG. 72.—Nine-spined stickleback (*Pungitius pungitius*)

and black dots develop here and there over the entire body. The male has also been described as assuming a rosy tint beneath.

General range.—This is one of the most widely ranging of northern fishes, occurring in both the fresh and salt waters of the northern parts of both hemispheres from northern Scandinavia to France on the European coast, from Arctic seas south to New York along the American coast, and westward to Saskatchewan and Alaska.

Occurrence in the Gulf of Maine.—This stickleback occurs all around the shores of the Gulf of Maine from Nova Scotia and the Bay of Fundy to Cape Cod, but so far as we can learn it is confined to the brackish creeks in salt marshes, where large numbers may often be taken in company with the mummichogs that swarm in such locations, and where it is to be found throughout the year, and to fresh water. In the Gulf of Maine it seldom or never ventures out into the salt waters of the open sea. About Woods Hole, too, it is distinctly a brackish and fresh-water fish.

Habits.—Hardly touching our Gulf proper, we need only note that its mode of life and feeding habits are much the same as those of its three-spined relative next to be considered (p. 168), that it is similarly destructive to the spawn and young of other fish, and similarly pugnacious. Probably this stickleback spawns early in

summer[95] on the shores of the Gulf, for in northern Europe its breeding season occurs in June and July. The male often but not always builds a nest attached to grass or weeds in which the female spawns, and he guards nest and eggs until the latter hatch, which occurs in about 12 days, the newly-hatched larvæ being about 6 mm. long.

Commercial importance.—This stickleback is of no commercial importance in America, but it is sometimes tried out for oil in north Europe when enough can be caught.

64. **Three-spined stickleback** (*Gasterosteus aculeatus* Linnæus)

TWO-SPINED STICKLEBACK; STICKLEBACK; PINFISH; HORNPOUT; GHOSTER; THORNFISH; THORNBACK

Jordan and Evermann, 1896–1900, p. 747.

Description.—The three-spined stickleback is a stouter fish than its nine-spined relative, being about one-fourth as deep as long, and is more compressed, but resembles it in fusiform outline, very slender caudal peduncle, and square tail fin. Its most diagnostic characters are the number of dorsal spines, of which there are three (occasionally four and very exceptionally five), with the first two usually much the larger, and each with a small triangular fin membrane; the small size of the anal spine (in the nine-spined stickleback this is long and free; in the four-spined long but attached to the fin by the fin membrane); and especially the presence of a series of 28 to 33 bony plates on the sides, and of a ventral plate between and behind the ventral fins. The fact that the dorsal fin originates some distance in front of the anal is also diagnostic, while its ventral spines are longer and stouter than those of the nine-spined stickleback. This is one of the most variable of fishes, Smitt [96] mentioning no less than 32 "species" or races based on its varieties. Its dorsal spines, for example, may be long or short and vary in number as noted above. Its bony plates range from none at all to very well developed ones. Its caudal peduncle may or may not be keeled. Most American authors have recognized an American as contrasted with a European species at the least, the former supposedly with longer dorsal spines, each of them reaching to the next behind when depressed, and the latter with shorter spines; but inasmuch as the long-spined as well as the short-spined form is known to occur on the other side of the Atlantic, with every possible gradation between the two, and seeing that we ourselves have found both in the Gulf among fish otherwise indistinguishable, we incline to the belief that all the various forms are but environmental races of the one species. And this is well established for the relative strength of the dermal armature, which is weak in fresh water and strong in salt water.

Color.—This fish is extremely variable in color, a fact hardly mentioned in most American accounts. Fundamentally it is deep grayish, olive, greenish-brown, or sometimes blue above, paler and often with silvery reflections on the sides, its belly silvery, and the fins pale, except that the fin membrane is often red. In breeding season the males are described as turning reddish below from nose to vent

[95] It spawns in April and May at Woods Hole.

[96] Scandinavian fishes, 1892.

and often up the sides. In females the whole body except the top of the back may then be reddish. At the same time the back turns brownish with transverse bands, and the sides develop brassy reflections.

Size.—Maximum length about 4 inches, but seldom more than 3 inches long. It matures at a length of 2 inches.

General range.—Coasts and fresh waters of the northern hemisphere, from Labrador to New Jersey on the eastern coast of America and represented on the northwestern coast by a form (*Gasterosteus cataphractus*) that will probably prove to be identical.

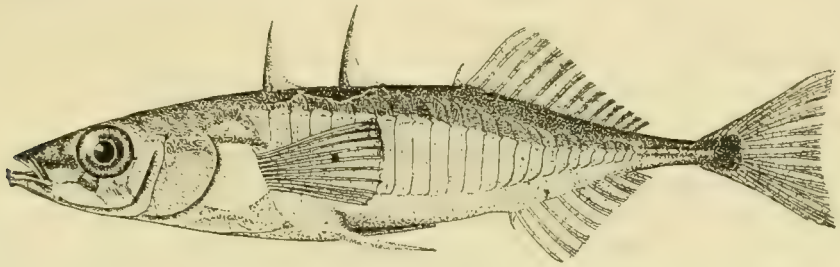

FIG. 73.—Adult

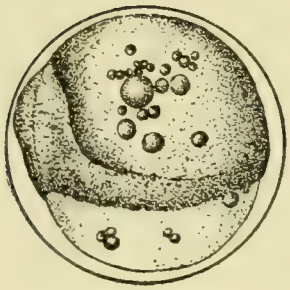

FIG. 74.—Egg

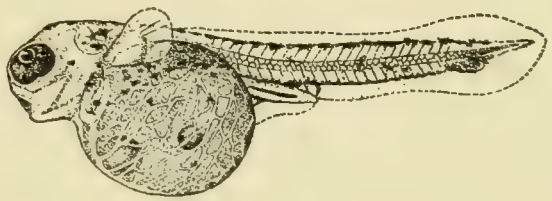

FIG. 75.—Larva, newly hatched, 4.3 millimeters

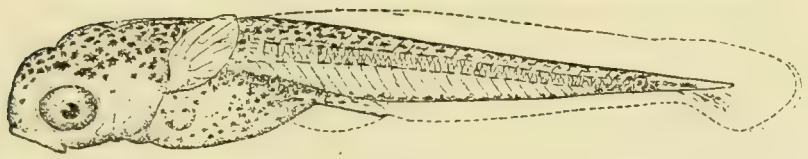

FIG. 76.—Larva, 6.3 millimeters

THREE-SPINED STICKLEBACK (*Gasterosteus aculeatus*)

Occurrence in the Gulf of Maine.—This stickleback is very plentiful all around the shores of the Gulf from Nova Scotia to Cape Cod, living indifferently in brackish and in salt water. The ditches and creeks of the tidal marshes, brackish ponds and lagoons, rock pools, and weedy shores in shallow water are its favorite habitats. In such places it may be found practically anywhere, and often in great numbers in company with killifishes and other sticklebacks, for it is the commonest of its tribe in the Gulf, as it is about Woods Hole. It is equally at home in fresh water on the one hand, and in sea water of full salinity on the other.

Like all sticklebacks it is distinctively a shore fish, the great majority of the local stock living their whole lives in estuarine waters. Enough stray out to sea, however, for it to be rather common to pick up a few here and there in the tow net, right out to the center of the Gulf. On such occasions they usually hide in clumps of floating eelgrass (Zostera) or rockweed (Fucus); indeed we have learned to expect a stickleback or two whenever we dip up bunches of weeds of any size. These wanderers keep to the surface except, perhaps, in very rough weather.[97]

Wherever found alongshore it is a permanent all-the-year resident, merely dropping down into slightly deeper water such as the bottoms of the deeper creeks to pass the cold months. In such situations it probably lies in schools in a more or less sluggish condition while the temperature is lowest.[98] It is proverbially a pugnacious fish, using its spines with good effect as weapons of offense and defense even on other fishes much larger than itself.

Food.—This fish feeds indiscriminately on the smaller invertebrates, on small fish fry, and on fish eggs, to which it is exceedingly destructive in fresh water. It is not only omnivorous but very voracious, the diet list of specimens examined by Vinal Edwards at Woods Hole including copepods, of which they are often full, isopods, schizapod shrimps, young squid, and some had fed on diatoms only.

Breeding habits.—This stickleback affords the classic instance of nest building and of the care of eggs among fishes, and its nesting has been described so often in popular natural histories that a bare outline will suffice here.[99] The spawning time is probably the same in the Gulf of Maine (May and June) as in North European waters,[1] when the fish assume the nuptial dress described above and the males fight fiercely. It is the male that builds the nest, selecting for this purpose some sheltered spot in shoal water or in some rock pool. Here he builds a barrel-shaped mass, an inch or so in diameter, of bits of grass, weed, etc., cemented together with mucous threads, which he spins from his kidneys, and weighed down with pebbles. To this nest he escorts one or a succession of females, each of them depositing 100 to 150 eggs in the central cavity. The male then enters the nest to fertilize the ova, which stick in clumps to each other and to the nest. Incubation occupies 6 to 10 days, during which period the male guards the nest, driving away intruders large or small. When hatching time approaches, however, he tears down the nest but continues to guard the fry until these can shift for themselves. The young fish are 4.25 to 4.5 mm. long at hatching time. In three or four days the yolk sac is absorbed, when a week old they are almost 8 mm. long, and when 6 weeks old and 14 to 16 mm. long the fry are of adult form with fins and spines fully formed.[2] This little fish is of no commercial value in America. In Scandinavia, however, it is sometimes seined in such quantities that it is worth boiling down for oil.

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[97] We have taken this stickleback on the eastern part of Georges Bank (Mar. 11, 1920); over German Bank; in the western basin (station 10307); off Cape Cod; near the Isles of Shoals; off Seguin; and off Matinicus; but in the Bay of Fundy it is known only close to land and off the mouths of estuaries.

[98] Large numbers are sometimes seined in winter in Scandinavian waters.

[99] Smitt (Scandinavian Fishes, 1892) and C. Tate Regan (The fresh-water fishes of the British Isles, 1911, XXV, 287 pp., Pls. I-XXXVII) give accounts of the nest building on which the following is based.

[1] About Woods Hole it spawns from May until the last week in July.

Figures of stages in development of this fish are given by Kuntz and Radcliffe (1918, p. 131), A. Agassiz (1882, p. 288, plate 9), and by Ehrenbaum (Nordisches Plankton, Band I, 1905–1909, p. 319)

65. Two-spined stickleback (*Gasterosteus bispinosus* Walbaum) [3]

Jordan and Evermann, 1896–1900 (*Gasterosteus gladiunculus*), p. 2836.

Description.—This stickleback is said to differ from the three-spined stickleback in having a deeper body, fewer rays (10 dorsal and 8 anal), fewer dermal plates (5 or 6 as against 28 to 33), unkeeled caudal peduncle, and a strong cusp at the base of the ventral spine both above and below. Dr. W. C. Kendall informs us that careful examination of large series has convinced him that this is actually a distinct species and not a race of the extremely variable three-spined stickleback, although he saw one specimen apparently intermediate between the two.

Color.—In life grass-green, mottled and finely punctated with black on the top of the head and back; sides of head and body golden with dark blotches; breast silvery; ventrals scarlet.[4]

General range.—Newfoundland to New York.

Occurrence in the Gulf of Maine.—Sticklebacks of this type are common in company with the three-spined in Passamaquoddy and St. Mary Bays [5] and in the Bay of Fundy. They may be expected anywhere on the Maine coast, being recorded at Winter Harbor, off Monhegan Island, off Seguin Island, from Casco Bay and its tributaries in both salt and brackish water, and from Kittery. It has also been taken at Swampscott, in Massachusetts Bay, and it is fairly common in summer at Woods Hole. To these coastwise localities we have added tow-net captures off Cape Porpoise, on Platts Bank, in the Western Basin, and on German Bank.

Habits.—So far as known its mode of life is the same as that of the three-spined species, and sticklebacks of this type have been described as building nests with bits of straw on sandy bottom in New York waters,[6] but so often have the two species or races been confused that nothing more definite can be written of its habits.

66. Four-spined stickleback (*Apeltes quadracus* Mitchill)

BLOODY STICKLEBACK

Jordan and Evermann, 1896–1900, p. 752.

Description.—The four-spined stickleback lacks dermal plates in its scaleless skin, but a bony ridge on each side of the abdomen makes the fish triangular in cross section,with flat belly and sharp back, and gives it an aspect very different from the other sticklebacks. In side view it is fusiform, tapering to the rather pointed nose and to the slim caudal peduncle. There are three free dorsal spines standing close one behind the other, inclining alternately to one or the other side, and a fourth attached to the dorsal fin by the fin membrane. The anal fin is similarly preceded by an *attached* spine, and each ventral fin is represented by a stouter curved spine succeeded

[3] This is the *Gasterosteus biaculeatus* of Cuvier and Valenciennes; *wheatlandi* of Putnam; *gladiunculus* of Kendall, but not the *G. bispinosus* of Jordan and Evermann, which is a variety of *G. aculeatus*.

[4] Kendall, 1896, p. 624.

[5] Huntsman, 1922a, p. 13.

[6] See Bean, 1903.

by about two slender rays. The dorsal fin stands above the anal as in the nine-spined species, but both these fins taper less from front to rear, and the caudal is relatively longer and narrower than in any of our other sticklebacks.

Color.—Brownish olive or greenish brown above with dark mottlings that alternate below the lateral line with the silvery white of the belly. The fin membrane of the ventrals is red. Males are much darker than females.

Size.—One and one-half to two and one-half inches long.

General range.—An American fish, known along the coast from New Brunswick and Nova Scotia to Virginia; at home both in salt and in brackish water and running up into fresh water.

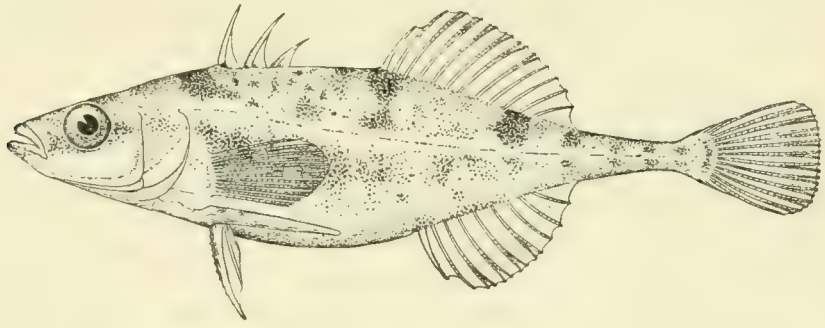

FIG. 77.—Adult

FIG. 78.—Egg

FIG. 79.—Larva, newly hatched, 4.3 millimeters

FOUR-SPINED STICKLEBACK (*Apeltes quadracus*)

Occurrence in the Gulf of Maine.—This stickleback is common all around the shores of the Gulf on the Nova Scotian as well as the New England side. We have taken it at Yarmouth, Huntsman (1922a, p. 13) records it from St. Mary Bay and along the New Brunswick shore, well within the Bay of Fundy (Maine has usually been given as its northern limit), and there are many locality records for the coasts of Maine and Massachusetts. It is so much more closely restricted to estuarine situations than is its three-spined relative (p. 168) that we have never taken it in our tow nets nor do we find a single record of it in the open sea, but it is a common little fish in the salt marshes of northern New England, where it consorts with other sticklebacks and with mummichogs. Like the three-spined stickleback it often runs up into fresh water, though it is primarily a salt and brackish water fish and is never found far in from the coast. On the south shore of New England

it is a year-round resident. Probably this is equally true in the Gulf, where it probably gathers in the bottoms of the deeper creeks in winter. So far as known it resembles the three-spined stickleback in its feeding habits (copepods and other small crustaceans being its chief diet) and in its general mode of life.

Breeding habits.—In the Woods Hole region this stickleback spawns as early as May and as late as the last week of July, after which spent females are found, but the onset of spawning may be delayed until somewhat later in the cooler waters of the Gulf. The males build a nest of plant fragments, cemented with mucus—a small rudimentary affair, however, compared with that of the three-spined stickleback—described by Ryder[7] as less than 1 inch in diameter, conical, with an opening at the top. In the manufacture it binds together, by a compound mucous thread which it spins out of a pore near the vent, a few stalks of any water plant, bringing bits of weed or other objects in its mouth from time to time to add to the structure. Finally it picks up the eggs and deposits them in the hollow at the top of the nest. Presumably the male guards nest and eggs during incubation. The latter, which are yellow and approximately 1.6 mm. in diameter, sink like those of the other sticklebacks and stick together in clumps. At laboratory temperature (about 70°) incubation occupies six days or thereabouts. Newly hatched larvæ are about 4.5 mm. long and similar in appearance to those of the three-spined species but more densely pigmented.[8]

THE TRUMPETFISHES. FAMILY FISTULARIIDÆ

The trumpetfishes are characterized by their slender bodies and tremendously long heads and by the fact that the anterior bones of the skull are prolonged in a very long tube with the small mouth at its tip. The only other Gulf of Maine species with which they could possibly be confused is the pipefish (p. 175). In the latter, however, the tubular snout occupies only about one-eighteenth of the length whereas in trumpetfishes it is nearly one-fourth.[9] Furthermore, the pipefish lacks and the trumpetfish has ventral fins, and the caudal fin of the latter is forked while that of the pipefish is rounded.

67. **Trumpetfish** (*Fistularia tabacaria* Linnæus)

CORNETFISH

Jordan and Evermann, 1896–1900, p. 757.

Description.—The slender body and very long snout of this fish are mentioned above. The body to base of caudal is about 34 times as long as deep and only about two-thirds as deep as thick. The head occupies almost one-third and the snout about one-fourth of the body length. The bones forming the latter are so loosely united that the snout is very distensible. The mouth is small, situated

[7] Bulletin, U. S. Bureau of Fisheries, Vol. I, 1882, p. 24.

[8] The early development is described by Ryder (Bulletin, U. S. Fish Commission, Vol. I, 1882, p. 24) and by Kuntz and Radcliffe (1918, p. 132).

[9] A specimen of the snipefish (*Macrorhamphosus scolopax* Linnæus), a European species with its chief center of abundance in the Mediterranean, was recorded at Provincetown in 1857; otherwise it is not known from the American coast. Should it again stray across the Atlantic it may be recognized by a long tubular snout like that of the trumpetfish but a short high body with two dorsal fins, the first consisting of one very stout and serrated spine and four smaller ones.

somewhat obliquely at the tip of the snout, and the lower jaw projects slightly beyond the upper. The caudal fin is deeply forked and its middle rays are prolonged in a filament about as long as the snout. Both the dorsal (14 rays) and the anal (13 rays) fins are triangular, higher than long, the former standing exactly above the latter, about two-thirds of the distance back from eye to base of caudal fin. The ventrals are much smaller—about midway between snout and tail. The skin is scaleless but is studded with bony plates or shields.

Color.—This fish (we have never seen it alive) is described as reddish brown above, the back and sides with many large, oblong, pale blue spots, the lower surface pale and silvery.

Size.—Said to reach a length of 6 feet, but the few specimens that stray northward are much smaller.

General range.—Tropical; common among the West Indies, rarely wandering northward as far as the Massachusetts Bay region.

Occurrence in the Gulf of Maine.—There is only one record of the trumpetfish from the Gulf of Maine—a specimen taken at Rockport, Mass. (north side of Cape

FIG. 80.—Trumpetfish (*Fistularia tabacaria*). After Storer.

Ann), in September, 1865, and preserved in the collection of the Essex Institute, where it was examined and identified by Goode and Bean (1879, p. 4). Like other tropical fishes, however, it is not so rare west of Cape Cod, a few small ones being taken at Woods Hole almost every year.

THE PIPEFISHES. FAMILY SYNGNATHIDÆ

In the pipefishes the anterior portion of the head takes the form of a long tubular snout with the small mouth situated at its tip, the skin is armed with rings of bony plates, and there is only one dorsal fin (soft rayed) and no ventrals. The snout recalls that of the trumpetfishes (p. 173), but pipefishes differ from them and from most other bony fishes in the structure of their gills, which take the form of tufts of small rounded lobes instead of the familiar filaments. In this respect their affinity is with the group of which the sticklebacks are the most familiar exponents. There are many species of pipefishes in warm seas, but only one occurs in the Gulf of Maine.

68. Pipefish (*Siphostoma fuscum* Storer) [10]

Jordan and Evermann, 1896–1900, p. 770.

Description.—This is a very slender little fish, particularly so behind the vent, males being about 35 times as long as deep and females about 30 times. The head is one-eighth to one-ninth the total length (in the trumpetfish it is nearly one-third); the snout is tubelike, blunt ended, and with the small toothless mouth at its tip. The gill openings are very small. The entire body is covered with an armor of bony plates connected in rings, of which there are 18 to 20 on the body in front of the vent and 36 to 42 on the tail behind the vent. It is heptagonal in cross-section in front of the vent and hexagonal behind it, a character evident when the fish is in hand. The abdomen of the male is wider just back of the vent than elsewhere, with two lateral flaps that meet along the midline to form the so-called "marsupial" or brood pouch. The female lacks these. The dorsal fin (36 to 40 rays and 5 or 6 times as long as high) covers 4 or 5 of the bony rings in front of the vent and as many behind it. The caudal fin is rounded, its middle rays the longest. The anal is very small, close behind the vent; the pectorals are of moderate size; there are no ventral fins.

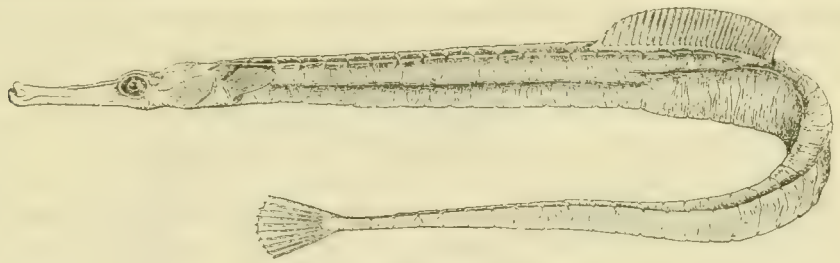

FIG. 81.—Pipefish (*Siphostoma fuscum*)

Color.—Greenish or olive above, transversely barred and mottled with darker. The lower parts of the gill covers are silvery. The lower sides are sprinkled with many tiny white dots, and the angle separating side from abdomen is marked by a longitudinal brown bar. The lower surface of the snout is colorless; thence back to vent pale to golden yellow, with the marsupial flaps flesh-colored. Dorsal and pectoral fins are pale, and the caudal is brown.[11] Pipefishes change color according to the color of their surroundings. We have seen them of various shades of olive and brown—even red ones having been described.

Size.—Usually 4 to 8 and occasionally up to 12 inches long.

General range.—Coast of eastern North America, in salt and brackish water, from Halifax, Nova Scotia, to North Carolina.

Occurrence in the Gulf of Maine.—Although Cape Ann has often been set as the northern limit of the pipefish, in reality it is not uncommon in the Bay of Fundy and has been recorded from many localities along the coasts of Maine and Massa-

[10] This is the only pipefish that occurs on our northern coasts. For a synopsis of the various other species of the genus see Jordan and Evermann, 1896–1900, p. 961

[11] Colors after Storer (1853–1867, p. 412), with which the specimens we have examined agree in general.

chusetts. Its chief home is among eelgrass or seaweeds, not only in salt marshes, harbors, and river mouths, where it often goes up into brackish water, but on more open shores as well. In such locations it is as often caught to-day by boys dipping mummichogs for bait as when Storer wrote of it nearly three-quarters of a century ago. The pipefish, like the three-spined stickleback, sometimes strays out to sea on the surface, and while we have never taken it in our tow nets, Kendall (1896, p. 623) has often found it under floating rockweed along the Maine coast. There is no reason to suppose the pipefish is at all migratory, for it is resident in the eelgrass (Zostera) at Woods Hole throughout the year.

So far as known pipefishes have few enemies. Perhaps they are protected by their noxious smell. They usually propel themselves by the dorsal fin, but when alarmed they can travel swiftly with eel-like strokes of the tail from side to side.

Food.—The pipefish feeds chiefly on minute Crustacea, copepods especially, which are often the sole contents of their stomachs according to Vinal Edwards' experience; also to some extent on fish ova, on very small fish fry, and for that matter no doubt indiscriminately on any small marine animals. Its snout is so distensible that it can swallow larger prey than one might expect. In capturing its prey it has been described as expelling the water from the snout and pharynx by muscular action, depending on the return rush to sweep its victims into its mouth.

Breeding habits.—On the southern shores of New England pipefish breed from March to August, and probably through this same period on the shores of the Gulf of Maine. Their breeding habits are so unusual that a whole literature has grown up about them.[12] Since the days of Aristotle it has been known that the pipefish nurses its eggs in the brood pouch (p. 175). It is the male that develops this pouch, the flaps of which lie flat against the concave belly out of breeding season, but are swollen and their edges cemented together during sexual activity. At each copulation, in which the male and female interwine together, the protruding oviduct of the latter is inserted into the opening of the pouch of the former and a dozen or more eggs passed over. A pair of fishes copulate several times in succession—with intervals of rest—until the pouch is filled, the male working the eggs down toward its posterior end by contortions of its body. Fertilization is supposed to take place during the transference of the eggs from one parent to the other. The eggs become embedded in the lining of the brood pouch, and it has been established for the European pipefish (probably this applies equally to our North American species) that the embryo within the egg is nourished by the epithelial lining layer of the pouch, so that the latter functions as a placenta.[13] Incubation occupies about 10 days, according to Gudger, and the young are retained in the brood pouch until they are 8 or 9 mm. long, when the yolk sac has been absorbed. The young pipefish are then ready for independent existence, and once they leave the pouch they never return to it, as young sea horses (Hippocampus) are said to do (p. 178). Several observers agree on this—most recently Miss Marie Poland (now Mrs. C. J.

[12] For a historical survey and a general account of the breeding of the closely allied *Siphostoma floridæ* see Gudger (Proceedings, U. S. National Museum, Vol. XXIX, 1906, pp. 447–500, Pls. V–XI).

[13] For detailed (if somewhat divergent) accounts of this interesting phenomenon see Huot (Annales des Sciences Naturelles, Huitième Série, Zoologie, Série 8, Tome XIV, 1902, pp. 197–288. Paris) and Cohn (Anatomischer Anzeiger, Centralblatt für die gesamte wissenschaftliche Anatomie, Band 24, 1904, pp. 192–199, 3 figs. Jena).

Fish), who kept pipefish under observation at the laboratory of the United States Bureau of Fisheries at Woods Hole during the summer of 1922.

Pipefish fry kept in aquaria have been found to grow from 10 mm. to 70 mm. in length within about two months after hatching.[14] Probably they mature when about 1 year old. Pipefish may be expected to breed in every favorable locality all around the shores of the Gulf, but there are local differences in this respect, for while St. Mary Bay, Annapolis Basin, and Cobequid Bay, on the Nova Scotian shore of the Bay of Fundy, are breeding centers according to Huntsman, large specimens alone are known about Passamaquoddy Bay on the New Brunswick side. No doubt the estuarine waters from the Massachusetts Bay region to Penobscot Bay are favorable nurseries.

Commercial importance.—The pipefish is of no commercial importance. It is not even good for bait.

THE SEA HORSES. FAMILY HIPPOCAMPIDÆ

69. Sea horse (*Hippocampus hudsonius* DeKay)

Jordan and Evermann, 1896–1900, p. 777.

Description.—With its laterally compressed body, its deep convex belly, its curved neck and curious horselike head carried at right angles to the general axis

FIG. 82.—Sea horse (*Hippocampus hudsonius*)

of the body, the sea horse grotesquely resembles the "knight" in an ordinary set of wooden chessmen. The head is surmounted by a pentagonal star-shaped coronet, and the snout is tubular with the small oblique mouth at its tip, like that of its relative the pipefish. There is a sharp spine on each side above and one behind the eye, a third over the gill cover, and a fourth on the side of the throat, which sometimes terminate in cirri, besides a blunt horn between the nostrils. Neck, body, and tail are covered with rings of bony plates, 12 rings on the trunk, 32 to 35 on the tail, and each body ring is armed with four blunt spines. The dorsal fin (about 19 rays) originates about midway of the length of the fish, opposite the vent, and runs backward over three and one-half rings—that is, to within half a ring of the commencement of the tail. The very small anal stands opposite the posterior

[14] Tracy, 1910, p. 93.

part of the dorsal. The pectorals are of moderate size, broad based and round tipped; there are no ventrals and no caudal fin. The body tapers suddenly behind the anal fin to a long tail, which is four-cornered in cross section, curled inward, and strongly prehensile. In the male the lower surface of the fore part of the tail bears the brood pouch opening by a slit in front.

Color.—Light brown or dusky to ashen gray or yellow, variously mottled and blotched with paler and darker—sometimes spangled with silver dots, sometimes plain colored. European sea horses change color according to their surroundings, tints of red, yellow, brown, and white all being within their capabilities, and it is probable that the American species is equally adaptable.

Size.—Adults are usually 3 to 6 inches long, one of 7¼ inches being the largest on record.[15]

General range.—Atlantic coast of North America, occurring regularly from South Carolina to Cape Cod, and to Nova Scotia as a stray.

Occurrence in the Gulf of Maine.—Although an occasional specimen has been picked up on Georges Bank and as far east as Nova Scotia, the sea horse is not common much beyond New York. Only a few are found each year about Woods Hole, chiefly in July, August, and September, and they so rarely stray past Cape Cod that we have only one definite (Provincetown) and one dubious (Massachusetts Bay) record of its capture in the Gulf of Maine, dead or alive.

Sea horses dwell chiefly among eelgrass and seaweed,[16] where they cling with their prehensile tails, monkeylike, to some stalk. They usually swim in a vertical position by undulations of the dorsal fin, not with the tail, the trunk being too stiff for much lateral motion.

Food.—Sea horses feed on minute Crustacea and on various larvæ—in fact on any animal small enough—sucking in the prey as does the pipefish (p. 176).

Habits.—These fish breed in summer[17] and the breeding habits resemble those of the pipefish, the male nursing the eggs in his brood pouch where they are deposited a few at a time by the female in repeated copulations. At hatching the young, of which there may be as many as 150, are about 10 to 12 mm. long. When the yolk sac is absorbed the father squeezes them out of the brood sac. According to some students they swim out and in at will, but this calls for verification. Within a few days after they are set free they already resemble the adult in general appearance.

Commercial importance.—The sea horse is of no commercial value but is an object of constant interest to visitors to marine aquaria.

THE SILVERSIDES. FAMILY ATHERINIDÆ

These are small fishes, smeltlike in appearance but with a spiny as well as a soft dorsal fin and with no adipose fin. Two species are known from the Gulf of Maine.

KEY TO GULF OF MAINE SILVERSIDES

1. About 24 rays in the anal fin ..... Common silverside, p. 179
   Only 15 or 16 rays in the anal fin ..... Waxen silverside, p. 181

[15] Bulletin, New York Zoological Society, Vol. XVI, No. 56, Mar., 1913, p. 972.

[16] Gill (Proceedings, U. S. National Museum, Vol. XXVIII, 1905, pp. 805–814) has given an excellent account of the habits and life history of the sea horse.

[17] Ryder (Bulletin, U. S. Fish Commission, Vol. I, 1881 (1882), pp. 191–199) describes its development.

70. Silverside (*Menidia notata* Mitchill)

YOUNG SMELT; GREEN SMELT; SAND SMELT; WHITEBAIT; CAPELIN; SPERLING; SHINER

Jordan and Evermann, 1896–1900, pp. 800, 2840.

Description.—This silvery little fish is often confused with the young smelt, but it does not require very close examination to tell them apart for the adipose fin characteristic of the smelt is lacking in the silverside, while the latter has a spinous as well as a soft dorsal fin instead of one dorsal only as in the smelt, this last character distinguishing it equally from young herrings. The silverside is a slender fish, about one-sixth as deep as long, not counting caudal fin; thin-bodied but with rounded, not sharp-edged, belly; with short head, large eye, and small mouth

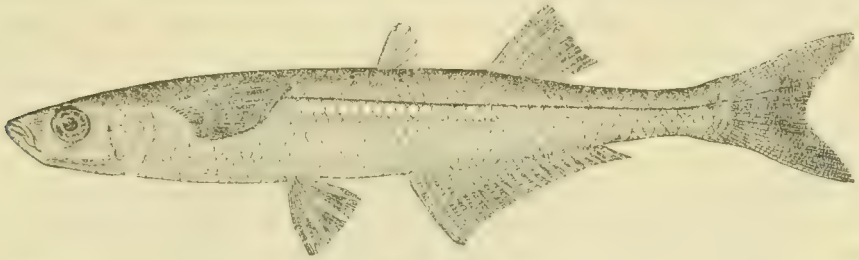

FIG. 83.—Adult

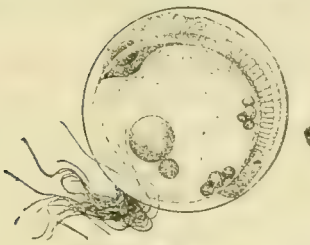

FIG. 84.—Egg

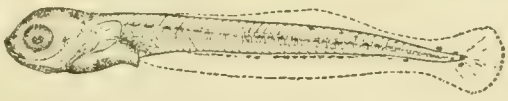

FIG. 85.—Larva, 8 millimeters

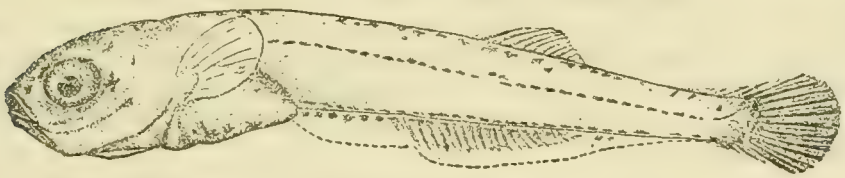

FIG. 86.—Fry, 13 millimeters

SILVERSIDE (*Menidia notata*)

set very obliquely. Both head and body are clothed with large scales. The first dorsal fin (5 spines) is smaller than the second and originates about midway between the tip of the snout and the base of the caudal fin; the second dorsal has 8 to 10 soft rays. The vent is under the middle of the first dorsal, and the anal fin originates under its last spine. The anal (of 24 rays, the first stiff and the others soft) is falcate in outline. The caudal peduncle is slender and the tail forked.[18]

[18] The common silverside is represented on the coasts of the eastern United States by two races, a southern and a northern, not, however, very distinct and connected by such various intergradations that they hardly deserve the two names with which they are usually dignified. The southern form has fewer scales than the northern, only 4 instead of 5 spines in the first dorsal, and is rather a stouter-bodied fish. Ken Iall has given an account of the genus in Report Commissioner of Fish and Fisheries, 1901 (1902), p. 241.

Color.—Translucent bottle green above, with top of head, nose, and chin dusky. The upper sides are thickly specked with dark brown, and there is a silver band outlined above by a narrow black streak, running along each side from close behind the pectoral fin to the base of the caudal. The belly is white.

Size.—The silverside grows to a length of 6 inches or more, adults usually being 4 or 5 inches long.

General range.—The northern variety of the common silverside is known from Halifax to the Capes of Delaware, south of which it gives place to intergrades or to the southern form, and the latter in its turn has been detected as far north as Woods Hole, but never east of Cape Cod.

Occurrence in the Gulf of Maine.—The silverside is to be found all around the shores of the Gulf from Nova Scotia to Cape Cod, always, however, closely confined to the coast line and as a rule within a few yards of the tide line. There is no reason to suppose that this fish ever ventures out to sea or descends deeper than a fathom or two. Many summers spent on the coast leave us with the impression that, generally speaking, the silverside is neither as omnipresent nor as abundant in the Gulf as it is south of Cape Cod. However, great schools of them are often to be seen along the sandy beaches, particularly in Cape Cod Bay and here and there on the Maine coast. Bushels have been caught in a single haul of the seine in Casco Bay and very likely could be elsewhere, but silversides are seldom seen along the stretches of rocky coast exposed to the open sea, which make up a large part of the shore line of the Gulf of Maine.

Silversides are extremely gregarious, congregating in schools usually made up of even-sized individuals. They frequent sandy or gravelly shores chiefly, and at high tide are often seen among the sedge grass (Spartina), where it grows sparsely between tide marks, particularly about the inner bays and in river mouths where they follow the tide up and down the beach within a few yards of the water's edge. They also run up into brackish water. The Bay of Fundy affords a good example of the influence the character of the shore line plays in determining the distribution of silversides, for according to Huntsman they are chiefly restricted to brackish water about St. Andrews but are more generally distributed on the New Brunswick shore further up the bay and on the Nova Scotian side as a whole. Silversides are probably resident throughout the year wherever found. Such, at least, is the case in southern New England.

Food.—Silversides are omnivorous, feeding chiefly on copepods, mysids, small shrimps, amphipods, fish eggs (including their own!), young squid, annelids, Cladocera, molluscan larvæ, and young prawns. Insects that fall into the water have also been found in their stomachs, as have algæ and diatoms mixed with sand and mud.

Breeding habits.[15]—Silversides spawn in May, June, and early July on the southern New England coast. Spawning may commence a little later in the Gulf of Maine, corresponding to lower temperature. The fish then gather in shoals to deposit their eggs on sandy bottom, often among the sedge grass or even above low-

[15] Kuntz and Radcliffe (1918, p. 127) describe its development, and Hildebrand (Bulletin, U. S. Bureau of Fisheries, Vol. XXXVIII, 1921-22 (1923) that of the southern race.

water mark. The eggs, 1.1 to 1.2 mm. in diameter, each bearing a bunch of sticky filaments, sink and stick fast in ropy clusters or sheets. Incubation occupied 8 or 9 days in the laboratory at Woods Hole. The yolk is absorbed before hatching, at which time the larvæ are about 3.85 to 5 mm. long. The dorsal, anal, and caudal fins are formed in larvæ of 12 to 15 mm. length. The young grew to a length of 9.3 to 11.7 mm. during the first 20 days in the aquaria. Probably they grow more rapidly at liberty, for all sizes from fry of an inch or less to adults are constantly to be found throughout the summer. Probably the silverside attains maturity at 1 year of age.

Commercial importance.—The chief function of the silverside in the economy of the sea is to feed the young of such predaceous fishes as bluefish and mackerel. North of Cape Cod the silverside is of no commercial value, being too small and too soft to answer the never satisfied demand for bait for offshore fisheries, but on the Rhode Island coast they are very generally used to bait eelpots, and they are excellent as "whitebait."

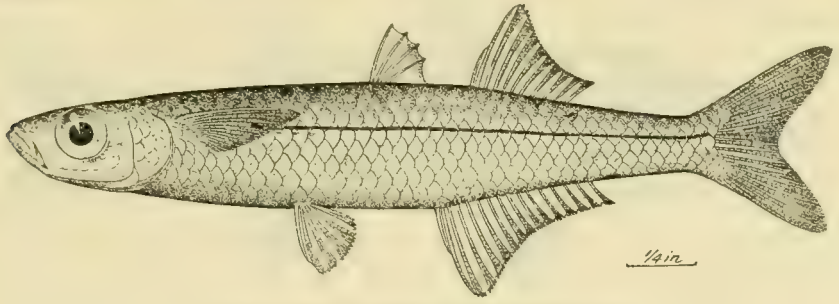

FIG. 87.—Waxen silverside (*Menidia beryllina cerea*)

71. **Waxen silverside** (*Menidia beryllina cerea* Kendall)

Jordan and Evermann (*Menidia gracilis*), 1896–1900, p. 797.

Description.—This species resembles the common silverside so closely in general appearance that it would be apt to be overlooked among the schools of the latter were it not paler in color and as a rule stouter bodied. A more dependable difference, one which will always serve to separate the two, for which neither color nor form can be relied upon, is that the anal fin is much shorter (only 15 or 16 rays) in the waxen than in the common silverside.

Color.—Described by Kendall (1902, p. 261) as "waxy, translucent, thickly punctated with black on top of head and back, dots on edges of scales, excepting those of throat, snout, and chin black from concentration of dots."

Size.—Smaller than *notata*, the specimens described by Kendall being less than 2½ inches long.

General range.—Cape Cod to South Carolina.

Occurrence in the Gulf of Maine.—Specimens reported by Kendall from Truro, and from Sandwich in Cape Cod Bay remain the only records for this fish within the Gulf of Maine, where it is apparently only a stray from warmer waters to the west and south. At Woods Hole, where it is abundant, its habits are the same as those of the common silverside, though it spawns somewhat later—that is, in June and July.

THE MULLETS. FAMILY MUGILIDÆ

Mullets have two separate dorsal fins, the first spiny and the second soft rayed. Their ventral fins are on the abdomen behind the point of insertion of the pectorals; their tails are forked and their scales large. Their closest affinity among the Gulf of Maine fishes is with the silversides, which they somewhat resemble in the relative sizes and locations of the fins; but they differ from them in having short, broad heads, small eyes, relatively deeper and thicker bodies, and only 24 instead of 35 or more vertebræ. Furthermore, they are vegetable and mud eaters instead of carnivorous, and, corresponding to their food, their stomachs are thick walled and gizzardlike, their intestines being long. The lining of the belly of the mullet is black while that of the silverside is pale.

There are many species of mullets. Most of them, however, are tropical, and only one has ever been known to stray within the confines of the Gulf of Maine.

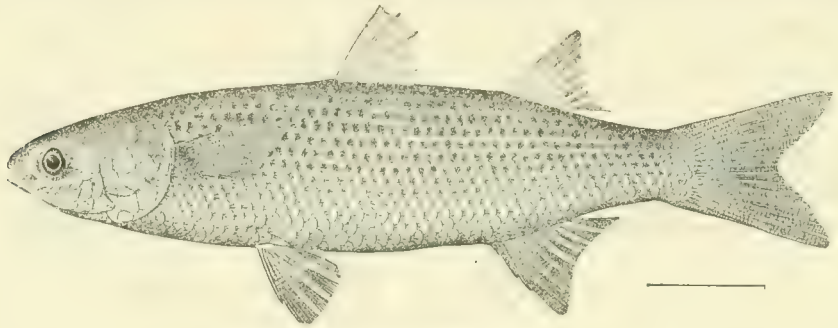

FIG. 88.—Mullet (*Mugil cephalus*)

72. **Mullet** (*Mugil cephalus* Linnæus)

COMMON MULLET; STRIPED MULLET; JUMPING MULLET

Jordan and Evermann, 1896–1900, p. 811.

Description.—The common mullet, the only one of its numerous tribe (there are more than 100 species of mullets) that has ever been known to stray north of Cape Cod, has a spiny first and soft second dorsal fin, the two well separated as in the silverside, and ventrals located on the abdomen, *not* on the chest. It is a much larger fish than the silverside, however, and even very young mullets of the size of the latter—4 to 5 inches long—are easily separable from them by the fact that the anal fin is only about half as long in relation to the length of the body, while the second dorsal originates over the origin of the anal instead of well behind it. Furthermore, the head of the mullet is shorter, its nose blunter, its profile quite different (compare fig. 83 with fig. 88), its eye smaller, its body stouter (about one-fourth as deep as long), and it lacks the silvery side stripes so characteristic of the common silverside. We need note further only that there are four spines in the first dorsal, one spine and eight soft rays in the second dorsal, three spines and eight (rarely seven) rays in the anal, that the first dorsal stands behind the tip of the pectorals, and that the tail is deeply forked. The soft dorsal and

anal fins are almost naked (in most other American mullets they are scaled), but the body and head are clothed with large rounded scales.

Color.—Described as dark bluish above, the sides silvery, with a conspicuous dark stripe along each row of scales; pale yellowish below, the ventrals yellowish and the other fins dusky.

Size.—In warmer waters the common mullet grows to a length of 2 feet, but only small specimens have been found along our northern coasts.

General range.—Both sides of the temperate Atlantic; from Cape Cod to Brazil on the American coast; also along the west coast of America from Monterey (Calif.) to Chili.

Occurrence in the Gulf of Maine.—Mullets are locally common as far north as Woods Hole, but so rarely do they stray past Cape Cod into the cooler waters of the Gulf that there are but a half dozen records of them there, viz, at Freeport, Harraseeket River, Clapboard Island, and Casco Bay in Maine, and at Essex [20] and Provincetown in Massachusetts, each based on an odd fish only. Mullet are more likely to visit the cool waters of the Gulf in late summer or early autumn than at any other season. They have been known to winter as far north as New York, hibernating in the mud, but it is not likely that the few strays that round Cape Cod survive the cold season, nor is there any reason to suppose they ever breed in the Gulf, for immature fish only are found at Woods Hole.

THE SAND LAUNCES. FAMILY AMMODYTIDÆ

The slender, round-bodied sand launces suggest small eels in general appearance. Eel-like, too, they lack ventral fins and swim with eel-like undulations from side to side. However, they are not even close relatives of the true eels, from which they are distinguishable at a glance by the large forked caudal fin, separated by a considerable space from both dorsal and anal, by the wide gill openings, and by the presence of a large bony gill cover, not to mention other anatomic characters equally important if less obvious.

73. **Sand launce** (*Ammodytes americanus* DeKay) [21]

SAND EEL; LAUNCE; LANT

Jordan and Evermann, 1896–1900, p. 833.

Description.—The sand eel is a slender little fish, its body about one-tenth as deep as the total length (not counting caudal fin), with long head and sharply-pointed nose, wide gill opening, and large mouth with the lower jaw projecting far beyond the upper. The jaws are toothless. There is one long low dorsal fin, soft rayed (about 60 rays; *no* spines), rising somewhat in front of the tip of the pectoral and running back along the whole length of the body nearly to the base of the caudal. The ventral (about 28 rays), similar in outline and equally lacking spines, originates slightly behind the middle of the dorsal and runs equally far back. The

[20] There is a specimen, so labeled, in the collection of the Boston Society of Natural History.

[21] Our sand eel is so closely allied to the common European launce (*Ammodytes tobianus*) that we doubt whether the distinction between the two—more slender form and longer head of *americanus*—will stand the test of time.

tail is deeply forked. The pointed pectorals are set very low down on the body and there are no ventral fins. The scales are small, lying in cross series on the sides of the body between numerous skin folds that run obliquely down and backward, and there is a low ridge of skin on either side along the belly.

Color.—Authors differ in their accounts of the colors of the sand eel, probably because, as with most fish, its iridescent luster fades at death and because it varies on different bottoms. Usually, as we can bear witness, it is olive, brownish or bluish green above with the lower sides silvery and the belly a duller white, while there may or may not be a longitudinal stripe of steel blue iridescence [22] on each side. The readiest field marks for the sand eel among Gulf of Maine fishes are its slender form and sharply pointed snout, coupled with long dorsal fin (separated, however, from the caudal) and the absence of ventral fins. The only

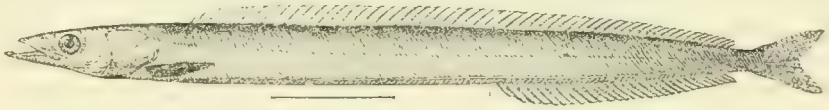

FIG. 89.—Adult sand launce (*Ammodytes americanus*)

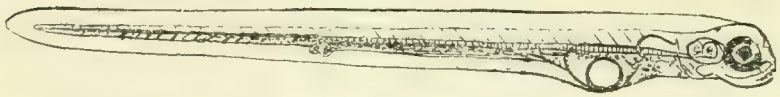

FIG. 90.—Larva of European *A. tobianus*, 6.6 millimeters. After Ehrenbaum and Strodtmann

FIG. 91.—Larva of European *A. tobianus*, 20.5 millimeters. After Ehrenbaum and Strodtmann

fishes with which one would be apt to confuse it are young eels, but in these dorsal, caudal, and ventral fins are confluent, not separate, and the tail is rounded, not forked.

General range.—North American coast, Cape Hatteras to Labrador. Its European relative occurs from Greenland, Iceland, northern Scandinavia, and the White Sea south to Spain.

Occurrence in the Gulf of Maine.—The sand eel is very plentiful along the coast from Cape Cod to Cape Sable wherever there are sandy shores, but it is seldom seen off the rocky parts of the coast line. Thus it is rather scarce in the Bay of Fundy except locally, but is common on the sandy beaches that here and there break the bolder northern shores of the Gulf, and swarms on the strands of Cape Cod Bay, a peculiarity of distribution associated with its habits. Launce must be extremely plentiful on Nantucket Shoals for many cod taken there by the *Halcyon* during the last week of June, 1923, were packed full of them. There are also sand eels

[22] In the European sand launce (*Ammodytes tobianus*), according to Smitt (Scandinavian Fishes, 1892), the sides, especially in young fish, are punctated with lines of tiny brown dots and the tip of the snout is blackish.

over the shallows of Georges and Browns Banks, whence they have been brought in to the Bureau of Fisheries by fishermen on several occasions.[23] They are very abundant on the Grand Banks, but there is no reason to suppose that they regularly inhabit the central deeps of the Gulf of Maine unless some of them repair thither in winter, though it would not be surprising to find an odd sand eel in deep water even in summer, as this happens in north European waters. In fact we towed a young one about 1¼ inches long over the deep basin southeast of Grand Manan on June 10, 1915.

The chief center of abundance for launce within the limits of the Gulf is along the shores of Cape Cod Bay. Here one may see schools of them throughout the summer in shoal water close in to tide mark, swimming with the curious undulating motion so characteristic of them. In some years they are also plentiful there during the winter, when great numbers are cast on the beach in stormy weather. About Woods Hole, too, sand eels are to be taken in shallow water on sandy flats throughout the year, but they are never as plentiful there in winter as in fall and spring; and since general diminution seems to take place in their numbers close inshore during the cold months in the northern part of their range, it is probable that a considerable proportion of the local stock moves out into deeper water for the winter, to return in spring, just as most of the launce do in north European seas. In Scandinavian waters this vernal inshore movement takes place in May as the coast waters warm up, and probably their schedule is much the same in the Gulf of Maine, judging from its temperature. On the other hand the sand eels may be expected to leave the shallower bays in midsummer when the water there is at its warmest, to work in again in early autumn, such being their habit about Woods Hole.

Habits.—The most interesting habit of the sand eel is its custom of burying itself several (4 to 6) inches deep in the sand, into which it burrows with great speed, thanks to its pointed snout. This the launce often does above low-water mark to await the return of the tide, where they are dug up by clammers, and I have often seen them vanish in this way with surprising rapidity when alarmed. It has been suggested that they spend a large part of the time so buried, and that their sudden appearances and disappearances, oft commented on, are to be explained thus, rather than as evidence of their wanderings or migrations. Whether this habit is followed only in the shoal water where it has come under direct observation, or whether they also burrow into deeper bottoms, is not known. The burrowing habit is for refuge, but is not always successful, for, as Smitt [24] remarks, porpoises have been seen rooting them out.

Sand eels are omnivorous, feeding on all sorts of small marine animals, but chiefly on small Crustacea, especially copepods, and on fish fry, including their own kind. In Scandinavian waters, indeed, the larger ones seem to live chiefly on the smaller. Worms have also been found commonly in the stomachs of sand eels, but it is not likely that they catch these while burrowing, as some writers have suggested.

[23] Report, U. S. Commissioner of Fish and Fisheries, 1879 (1882), pp. 808, 812, 814, and 817

[24] Scandinavian Fishes, 1892.

The sand eel plays a very important rôle in the economy of northern seas as food for larger animals. Finback whales devour them greedily when they find them in abundance. Such an occasion occurred in Cape Cod Bay in June, 1880, when launce appeared in swarms early in the month followed by finbacks a few days later. Porpoises, too, and sundry predaceous fish such as cod, haddock, halibut, silver hake, salmon, mackerel, and bluefish find them a staple article of food. When fleeing from their pursuers, especially from the silver hake, which does not hesitate to follow right up on the sand, they often strand in such multitudes as to cover the flats with a sheet of silver.

Sand eels' noses are so sharp that when swallowed by cod, and perhaps by other fish, they sometimes work right through the stomachs and into the body cavities of their captors, to become encysted in the body wall, but this must be an exceptional event for none of the fishermen of whom we have inquired have seen it, nor have we.

Breeding habits.—So far as we can learn, the eggs of the American sand eel have not been seen,[25] nor has its spawning been observed. In the case of the European form (*tobianus*) ripe specimens, both male and female, have been taken throughout the year, a phenomenon that has given rise to widely differing views as to its spawning season. The chief production of eggs of the latter, however, at least in the southern part of the North Sea, takes place in autumn and early winter as Ehrenbaum [26] demonstrated, both by dredging them in large numbers and by the fact that its larvæ are extremely abundant there from January to March, but have seldom been taken at other seasons.

Judging from the evidence afforded by the occurrence of larvæ, the season is about the same for the American form as for the European, as might be expected. Thus its eggs must begin hatching in midwinter, if not earlier, at Woods Hole, for fry are taken there in March. Probably this applies equally to the western part of Georges Bank, where the *Albatross* towed a number of larvæ of from 11 to 17 mm. on February 22, 1920. The season is progressively later to the northward, however, for we have taken larvæ but a few days old (7 to 8 mm. long), with the yolk still showing, off Newburyport, Mass., on March 4, 1921, and the Canadian Fisheries Expedition of 1915 obtained an abundance of but slightly older stages (7 to 15 mm.) off the southeast coast of Nova Scotia in May. Launce were formerly thought to spawn on sandy beaches above low-water mark while burrowing in the sand, but their eggs have never been found in such situations, and Ehrenbaum proved, by dredging them in large numbers, that those of the European species, *Ammodytes tobianus*, are actually deposited in depths of 10 fathoms or so on sandy bottom where they stick fast to the grains of sand. His experience suggests that they resort to very definite grounds for spawning, all of which probably applies as well to the American as to the European form.

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[25] Hind (Fishery Commission, Halifax, 1877, part 2, p. 7) describes the launce in the Gulf of St Lawrence as "depositing their large reddish-colored ova on the sand between high and low water." This account, however, is widely at variance with the spawning habits of their European representative (*Ammodytes tobianus*) and with the seasonal occurrence of their larvæ (p. 180), and was probably borrowed from the larger European sand eel (*Ammodytes lanceolatus*).

[26] Wissenschaftliche Meeresuntersuchungen, Helgoland, Neue Folge, Band 6, 1904, p. 184.

The eggs of the latter are oval, 0.72 to 0.97 mm. in greatest diameter, with a yellow oil globule of 0.25 to 0.31 mm., and are usually described as of an orange tint. The larvæ are very slender, and about 7 mm. long by the time the yolk is absorbed. The dorsal and anal fin rays are visible at about 16 mm., but the fins do not assume their final outlines until the young fish are upwards of 25 mm. long. The early larval stages are easily recognizable by their slender form combined with the fact that the vent opens at one side and not at the margin of the larval fin fold, so that it apparently ends blind just as among the cod tribe. The older larvæ much resemble the corresponding stages of the rock eel (p. 362) in their slim form and in the location of the vent slightly behind the middle of the trunk (in the similarly elongate larvæ of the herring tribe it is located farther back), but may be recognized by the row of black pigment cells along the *dorsal* instead of the *ventral* side of the intestine (p. 362), and by their pointed noses. The dorsal and anal fin rays are visible when the larva is about 18 mm. long, but while the full number of the latter are formed early, in the case of the dorsal fin the rays behind the vent are considerably developed before those farther forward appear; and it is not until the little fish is upwards of 25 mm. long that the tail begins to assume its forked outline, this fact being a convenient field mark for distinguishing between the launce and the herring, in which the tail is deeply forked from a much earlier stage.

We have taken larval launce at only four stations in the Gulf, and then in small numbers, an apparent rarity surprising with the adults so plentiful and with young launce perhaps the most abundant of all fish fry in European seas. It remains to be seen whether the Gulf of Maine actually is not a prolific breeding ground but depends on immigration from elsewhere for the maintenance of its stock of launce, or whether we have simply missed them by towing at the wrong time or place. The rate of growth has not been studied. The young ones of 3 to 4 inches, which are plentiful from July until September, are probably yearlings, while those of 5 inches and upward are probably 2 years old.

Commercial importance.—It is only for bait that sand eels are of any commercial value in the Gulf, for which purpose 67,800 pounds were landed from the traps in Massachusetts in 1919.[27]

THE MACKERELS. FAMILY SCOMBRIDÆ

The mackerels are a very homogenous group, all of them agreeing in the possession of a spiny as well as a soft dorsal fin, several small finlets behind the latter and behind the anal, a very slender caudal peduncle, a deeply forked or lunate caudal fin, a very shapely form tapering both to snout and to tail, and velvety skin with small scales. All, too, are predaceous, swift swimmers, and powerfully muscled, while all are fish of the open sea and more or less migratory.

In the following key we mention all species so far actually recorded from within the limits of the Gulf of Maine, but it would not be surprising if still others were to stray in from the open Atlantic on occasion.

[27] A second species of launce (the Arctic *Ammodytes dubius* Reinhardt) has been reported from Boston by Günther (1862), and from Woods Hole by Smith (1898), but it is probable that the specimens in question were merely large *Ammodytes americanus*. In fact it is doubtful whether there is any sound distinction between the *A. dubius* of Greenland and the European *A. tobianus* on the one hand, or the American *A. americanus* on the other.

KEY TO GULF OF MAINE MACKERELS

1. The two dorsal fins are separated by a space as long as the length of the first dorsal 2
   The two dorsal fins adjoin each other or are separated by a space much shorter than the length of the first dorsal 3
2. The sides below the mid line are silvery, not spotted ..... Mackerel, p. 188
   The sides below the mid line are mottled with dusky blotches ..... Chub mackerel, p. 209
3. Body scaleless, except for a so-called "corselet" in the region of the shoulders ..... Bonito (Gymnosarda), p. 211
   The entire body is covered with scales 4
4. The second dorsal fin is as high as the first or higher 5
   The second dorsal fin is lower than the first ..... Bonito (Sarda), p. 215
5. The anal fin is about twice as high as long; the corselet of large scales is obvious; the sides, are not spotted ..... Tuna, p. 212
   The anal fin is about as long as high; there is no corselet of large scales; the sides are spotted 6
6. The anterior part of first dorsal fin is black, with the division between the dark and pale portions roughly vertical; about as many spots above as below the lateral line ..... Spanish mackerel, p. 217
   The upper half of the first dorsal is deep blue, with the division line between the dark and pale portions horizontal. Most of the spots are below the lateral line. King mackerel, p. 219

74. **Mackerel** (*Scomber scombrus* Linnæus)

Jordan and Evermann, 1896–1900, p. 866.

Description.—The mackerel is fusiform in outline, tapering rearward to a very slim caudal peduncle and forward to a pointed nose. Its body is about three and one-half times as long as deep, oval in section, thick, and firm-muscled as are all its tribe. Its head is long (one-fourth of total length) and its mouth large, gaping back to the middle of the eye (the premaxillaries are *not* protractile), while the jaws, which are of equal length, are armed with small, slender, but very sharp teeth. The eye is large, and the hollows in front of and behind it are filled with the so-called "adipose eyelid," a transparent, gelatinous mass in the form of two scales, a forward and a hinder, which cover the eye except for a perpendicular slit over the pupil. There are two large dorsal fins—the first triangular, originating over the middle of the pectoral fin when the latter is laid back, of 10 to 14 (usually 11, 12, or 13) rather weak spines that can be laid down along the midline of the back in a deep groove; the second, separated from the first by an interspace longer than the length of the latter, is smaller (9 to 15, usually 12, rays) and is followed by several small finlets, of which there are usually 5 but sometimes 4 or 6. The anal is similar to the second dorsal in shape and size, originates slightly behind it, and is similarly succeeded by 5 small finlets that correspond to the dorsal finlets in size and shape. The caudal fin is broad, but short and deeply forked. The caudal peduncle bears two small keels on either side but *no median lateral* keel, the absence of the latter being a distinctive character. The ventral fins stand below the origin of the first dorsal and like the pectorals are small. The scales of the mackerel are so small that its skin is velvety to the touch; indeed, on the belly they are hardly to be seen with the naked eye, but those about the pectoral fins and shoulders are somewhat larger.

Color.—The upper surface is dark steely to greenish blue, often almost blue-black on the head. The body is barred with 23 to 33 (usually 27 to 30) dark trans-

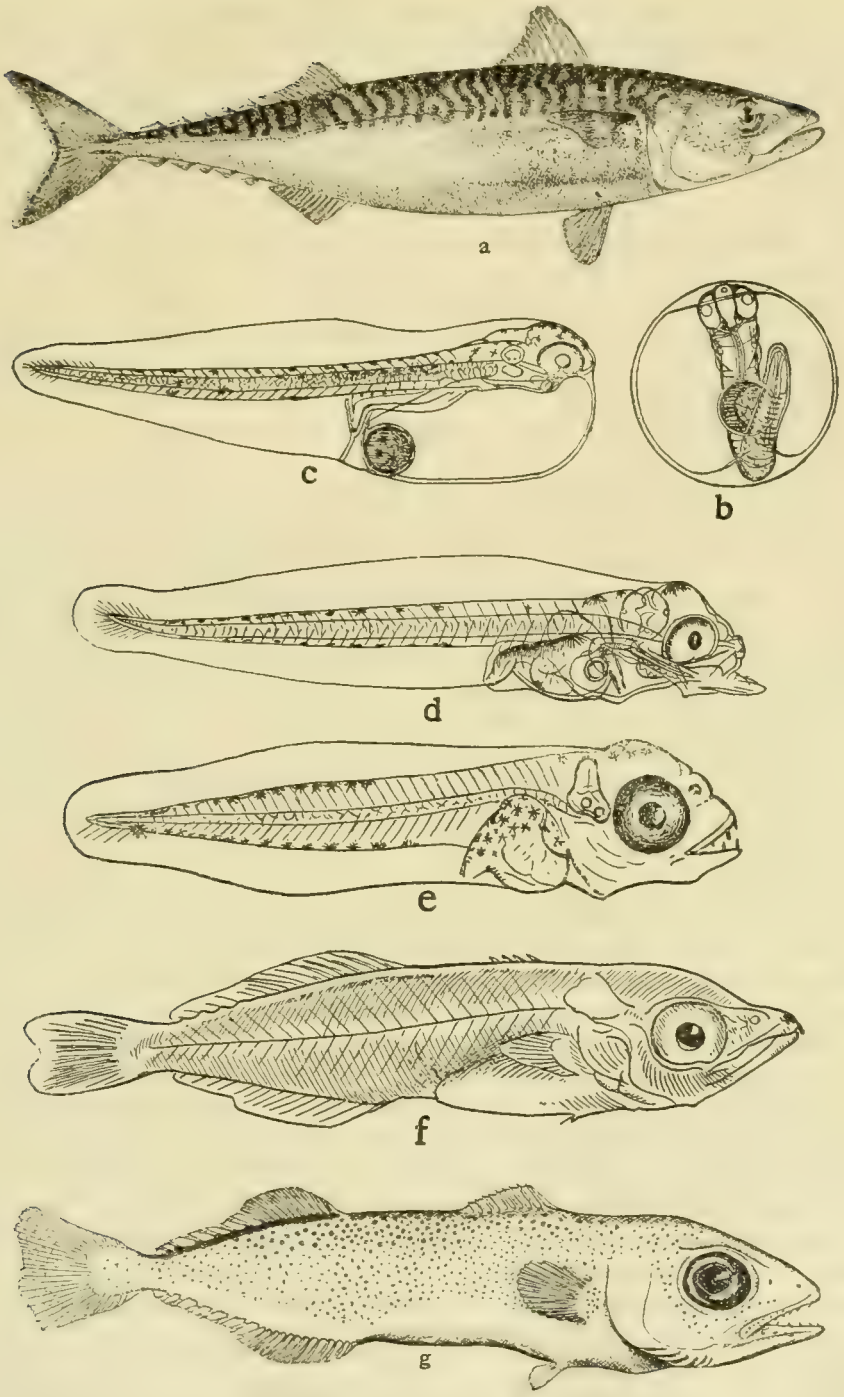

FIG. 92.—Mackerel (*Scomber scombrus*)

a, Adult. *b*, Egg. After Holt. *c*, Newly hatched larva, 3.5 millimeters. After Holt. *d*, Larva, 4.5 millimeters. After Holt. *e*, Larva, 6 millimeters. After Ehrenbaum. *f*, Larva, 14 millimeters. After Holt. *g*, Fry, 22 millimeters.

verse bands [28] that run down in an irregular wavy course nearly to the midlevel of the body, below which there is a narrow dark streak running along each side from pectoral to tail fin. The pectorals are black or dusky at the base, while the dorsals and caudal are gray or dusky. The jaws and gill covers are silvery. The lower sides are white with silvery, coppery, or brassy reflections and iridescence, and the belly silvery white, but the iridescent colors fade so rapidly after death that a dead fish gives little idea of the brilliance of a living one.

Size.—Mackerel have been recorded up to 20 inches long and weighing as much as 3½ pounds. One of that length, measured by Doctor Kendall on Georges Bank, was 11½ inches in circumference, but an 18 or 19 inch fish is above the average, the adults running from 13 to 14 inches and upward. One a foot long weighs 12 to 16 ounces.

General range.—Both sides of the North Atlantic—Norway to Spain off the European coast,[29] and from southern Labrador to Cape Hatteras off the American coast.

Occurrence in the Gulf of Maine.—At one time or another the mackerel is practically universal in the Gulf of Maine, for not only does it appear in great abundance on the offshore grounds—that is, Nantucket Shoals, Georges and Browns Banks—and all over the central deeps, but also throughout the coastal belt; and while the adult fish seldom venture within the outer islands or headlands, good catches are sometimes made well up Penobscot Bay, and young ones 6 to 10 inches long often swarm right up to the docks in summers of plenty, such as 1922, when a great abundance of them was taken.

It is impossible to outline any particular subdivisions of the inner Gulf as prolific or barren of mackerel, for the fish congregate in different regions from year to year. The Bay of Fundy, for example, once a famous mackerel ground, was so nearly deserted for some years after 1876 that fishing was abandoned there. Of late years, however, large schools are often seen on the Nova Scotian side, and some right up to the head, but comparatively few are reported on the New Brunswick shore. In years when the mackerel come well inshore, Massachusetts Bay is usually a center of abundance both early and late in the season, with the fish schooling irregularly there during the summer as well. Both seiners and hook and line fishermen have found prolific grounds in the neighborhood of Boon Island, off Cape Elizabeth, from Monhegan to Matinicus Island, and near Mount Desert Rock. During some summers the mackerel are reported mostly within 30 to 40 miles of land in the Gulf of Maine; in other years most of them stay offshore. In 1882, for example, a year of great abundance, vast schools were found over the offshore deeps of the Gulf between Georges Bank, Browns Bank, and Cashes Ledge, and thence northward to within 40 miles or so of the Maine coast, most of the early season catch being made in this deep water and in the weirs along the west coast of Nova Scotia. Later in the season, however, the fish disappeared.

[28] Hunt (Copeia, No. 117, pp. 53–59, April, 1923) describes the variations in these stripes among young mackerel caught off Long Island, New York, in November, 1922.

[29] There is a fairly constant racial difference between American and British mackerel (Garstang, Journal, Marine Biological Association of the United Kingdom, Vol. V, New Series, No. 3, 1898, pp. 235–295), the former showing more transverse bars, being more often spotted between them, and more often having 6 instead of 5 dorsal finlets.

Plentiful though mackerel sometimes are in the inner waters of the Gulf of Maine, still larger numbers are found over Nantucket Shoals and Georges Bank and off the outer coast of Nova Scotia, but with much variation in the local abundance from year to year, as appears from the following table for two successive seasons when the total catches from the whole Gulf of Maine region did not differ greatly. This table comprises the landings of mackerel at Boston and Gloucester, Mass., and Portland, Me., by the vessel fishery in 1916 and 1917.

Locality	1916	1917
Georges Bank	3,701,597	624,086
South Channel	77,157	13,600
Nantucket Shoals	2,516,414	6,277,830
Off Chatham	2,017,753	3,938,452
Off Race Point	99,250	621,751
Stellwagen Bank	1,559,972	519,550

General migrations.[30]—Wherever the mackerel occurs, whether in American or in North European waters, it is a seasonal migrant, appearing near the coast in spring, to vanish thence in autumn. The directions and extent of the journeys which it carries out have been the subject of much discussion ever since the fishery first assumed importance, because of their intrinsic interest, their bearing on the prosecution of the fishery, and because this fish has been the subject of much international dispute, but although a vast number of observations have been made and many pages written on the subject, the knowledge sufficiently exact to clear all aspects of the question is still lacking. The point chiefly at issue has been whether the main bodies of mackerel merely sink and move directly out to the nearest deep water, when they leave the coast, or whether, and to what extent, they combine their offshore and onshore journeys with the north and south migrations in which most fishermen believe.

It seems well established, however, and is now generally accepted, that the coastwise journeys of the mackerel are not as extended as was once believed, but that the schools that visit the Gulf of Maine are not the same fish that are seen earlier south of New York, and that the Gulf of St. Lawrence mackerel are still another body. The most direct evidence that no general movement takes place from south to north along the coast, but that the arrival of mackerel in spring is in the nature of successive waves coming in from more and more northerly parts of an extensive wintering ground, is that although they appear earlier and spawn earlier west of Block Island, the adults are either green or near spawning condition on their first arrival in the Gulf of Maine and farther east, never spent, as they would be had they come up the coast spawning en route; and, as several of our predecessors have remarked, it is certain that the mackerel spawning in the Gulf of St. Lawrence in July can not be the same fish that spawn off New England in May and June. The fact that mackerel appear practically simultaneously off Cape Cod and southern Nova Scotia, and that in some years, at least, they are reported as early at Cape Breton and even in

[30] The literature dealing with this subject is very extensive. See especially Goode, Collins, Earll, and Clark (1884) and Tracy (Thirty-seventh Annual Report, Rhode Island Commissioners of Inland Fisheries, 1907, p. 43) for the American mackerel.

the Gulf of St. Lawrence as at Cape Sable[31] (or earlier), also argues that the fish have not come from the southwest but from offshore, for did they cross the mouth of the Gulf of Maine en route they might be expected to show earlier in its western than in its eastern side. Furthermore, mackerel summer in and off the Gulf of Maine instead of appearing there only as spring and autumn visitors. We may add that there is no evidence of any general movement west and south from the Gulf of Maine region in autumn. The mackerel simply disappear. For that matter mackerel are seen and caught off Nova Scotia even later in the season than off Cape Cod, just the reverse of what might be expected if they carried out a general north and south migration along the coast.

From evidence of this sort, from the breeding habits of the fish (p. 206), and from the winter habits of the European mackerel to be mentioned later (p. 196), scientific opinion has gradually crystallized to the effect that the essential features of the seasonal migrations of the mackerel are essentially a spawning journey inshore and into shallow water in spring, alternating with an offshore movement combined with a descent into deep water in autumn.

According to geographic conditions these fundamental changes of situation are accompanied by horizontal journeys of greater or less length and of various directions but *not* necessarily north and south. In the case of the bodies of fish that are seen south of New York the journey in and out is nearly east and west and perhaps not more than 50 to 60 miles in some cases, but for the schools that visit the inner parts of the Gulf of Maine the journey probably covers 200 miles each way while its route is roughly north and south. At least a part of the Gulf of St. Lawrence mackerel have a still longer journey, for it is probable that these fish follow the outer coast of Nova Scotia southwestward for some distance in the autumn and possibly even as far as Cape Sable before they turn out to sea. The case is made more complicated by the strong probability that while the feeding migrations of the Gulf of Maine and of the Gulf of St. Lawrence fish do not carry them out of these general areas until it is time for them to seek winter quarters, the southern mackerel (that is, those spawning south of New York) may travel along shore toward the northeast after spawning, for mackerel disappear off this part of the coast after a brief stay—by June at the latest—not to reappear there until the following spring; and though all knowledge of the habits of this fish, combined with ocean temperatures and with the distribution of their prey, make it more likely that they work northeastward toward the rich feeding grounds of the Nantucket Shoals and Georges Bank regions than that they move out to summer over the Continental Slope south of the latitude of New York, there is no reason to suppose that any of them journey farther east or enter the Gulf of Maine.[32]

According to general report mackerel seeking the inner part of the Gulf of Maine follow two main routes after they first show themselves in spring, either keeping to the western side along Cape Cod, or coming in along Browns Bank and the west coast of Nova Scotia. Their inward migration covers a period of some weeks, the

[31] According to Huntsman (1922b) mackerel appeared at Cape Breton on May 5, at Gaspé (on the Gulf of St Lawrence) on May 12, and off Yarmouth, Nova Scotia, on May 16, in 1894.

[32] We have found no positive record of mackerel taken in late summer anywhere south of Delaware Bay, although they are plentiful off this part of the coast in spring. Bell and Nichols, it is true, speak of "mackerel" as found in tiger-shark stomachs off North Carolina (Copeia, No. 92, Mar., 1921, pp. 18–19), but Mr. Nichols writes us that these were "just Scombroids and probably not *Scomber scombrus*."

first comers being recruited later by part of the schools that are seen on Nantucke Shoals and Georges Bank in May, but it seems certain that considerable bodies of mackerel remain on these offshore grounds all summer, both spawning and feeding there, these, with the recruits they may receive from the south during the years of plenty, providing good fishing there any time from June to September.

An interesting question is whether a given school returns summer after summer to the same general part of the coast (that is, to the Gulf of Maine), or whether there is considerable interchange and a wide shifting of grounds. Within moderate limits the last alternative is probably the correct one, but experience on the other side of the Atlantic, where it has been possible to recognize local races of mackerel,[33] makes it seem very unlikely that fish resorting to the Gulf of Maine or its offshore banks one summer would visit a region as far afield as the Gulf of St. Lawrence another.

On their spring migration the European mackerel usually keep to the bottom until close in to land before rising to the surface. This generalization does not apply to the American fish, however, for while some swim deep—so, only, can we account for the fact that the first schools often show as early in Massachusetts Bay as on Georges Bank or off Nantucket—mackerel in much greater numbers come to the surface as far out as the edge of the continental shelf in spring, and this all the way from the latitude of Cape Hatteras to the mouth of the Gulf of Maine.

Date of appearance.—The first mackerel are expected off the Chesapeake Bay–Cape Hatteras region at any time between March 20 and April 25; off the Delaware Capes during the last half of April; off southern New England in May. May 10 may be set as about the average date of their appearance in the southern part of the Gulf of Maine, and they are usually plentiful on Nantucket Shoals by that time. The date of their appearance may vary a week or more in either direction in different years. In 1898, for instance, mackerel were reported simultaneously at Chatham on Cape Cod and at Yarmouth, Nova Scotia, on May 2; in 1901 they were seen off Chatham on April 29; and in 1922 the first schools were sighted south of Cape Sable on May 11 and off Yarmouth on the 7th; but if it is fated to be a good mackerel year the fish are plentiful in most parts of the Gulf of Maine by the end of May or the first week in June at the latest, except in the Bay of Fundy where few appear until well into the latter month.

Movements in summer in the Gulf of Maine.—Though we can not offer definite evidence to this effect, it is safe to say that after they once appear on the coast the wanderings of the immature mackerel are wholly governed by their search for food. This is equally true in the case of the large fish after spawning is completed, that is, during the last half of the summer, but when the latter first arrive the case is complicated by their sexual activity (p. 206). General report has it, on the basis of the gill-net and pound-net catches (and there is no reason to doubt this), that the adult mackerel that spawn in Massachusetts Bay come in around Cape Cod, but that other bodies swim directly in to the coast of Maine, and that the fish bound for the Bay of Fundy and for the northeast corner of the Gulf generally,

[33] The American mackerel does not split up into local races.

follow the west coast of Nova Scotia (p. 192). After the large fish that breed in the Massachusetts Bay region are spawned out it seems that most of them move out either into the open Gulf or northward up the coast of Maine, for in midsummer and early autumn the hook-and-line fishing used to be most productive between Cape Elizabeth and Mount Desert Rock, notably about Monhegan Island and offshore as far as Cashes Ledge. In years of plenty, however, the smaller fish are to be caught all along the coast throughout the summer as noted elsewhere (p. 190).

Half a century ago, during the days of the hook-and-line fishery, there would have been no need to emphasize the fact that large as well as small mackerel summer in the Gulf of Maine. To-day, however, when the American fishery is carried on chiefly with purse seines and nets, and when, consequently, the schools are seldom caught or reported except when near the surface, there is a widespread view that they largely desert the Gulf for a longer or shorter period some time during the

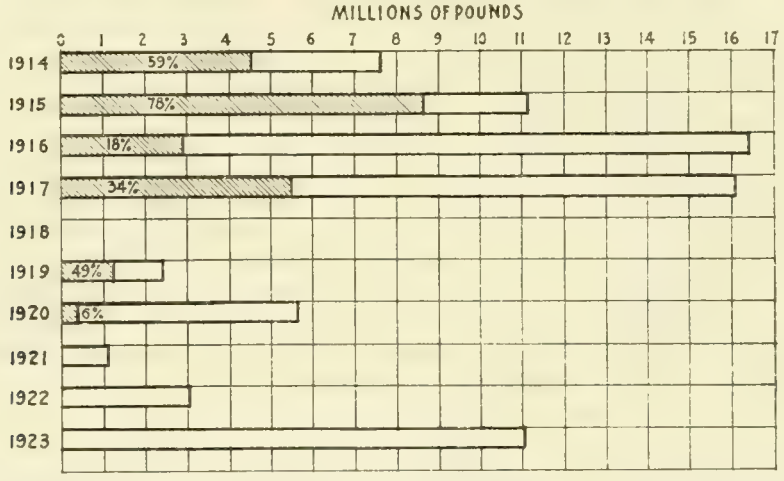

FIG. 93.—Total landings, in pounds, of mackerel (solid line) at Boston, Gloucester, and Portland, from grounds west of 66° longitude and tributary to the Gulf of Maine. Also percentage of the catch that consisted of fish smaller than 1½ pounds

summer, for they generally disappear then for a time. In 1906, for example, the schools vanished from the Massachusetts Bay region in June, to reappear the 27th of July, on which date 28 seiners made catches ranging from 18 to 250 barrels each; and in 1892, a year of abundance, they disappeared (that is, sank) in August, not to appear again in any abundance anywhere in the Gulf of Maine until October. During other years, however, they school at the surface all summer long.[34] Since good catches of mackerel were formerly made on hook and line in one or another part of the Gulf right through the season from June to October, even when none showed on the surface, these summer disappearances merely mean that the fish have sought lower levels in the water or that they have wandered to some other part of the Gulf; and perhaps the schools have dispersed more or less, for the comings and goings of the mackerel are proverbially erratic.

[34] 1882 was an example of this.

The vertical movements of the fish during their summer stay (that is, their appearances on the surface and descents to lower levels) are no doubt governed chiefly by the level at which food is most abundant, and there is no reason to suppose that they ever descend more than a few fathoms during their stay, the supply of small crustaceans on which they feed (p. 201) being invariably richer above than below 50 fathoms depth in the Gulf of Maine. As yet no attempt has been made to correlate, on a definite statistical basis, the local abundance or reverse of the American mackerel and the precise depths at which they swim with the supply of available food, but fishermen have long appreciated the fact that mackerel are most apt to be plentiful where there is a good supply of "red feed" (copepods) or other small animal life in the water, and a relationship has been found to hold in the English Channel between the catches of mackerel and the numbers of copepods present in the water,[35] mackerel being plentiful when there is a plentiful supply of the latter. To go one link further back in the chain of cause and effect, Allen [36] found that the more hours of sunshine in February and March (hence the more diatoms to support copepods), the more mackerel were caught off Plymouth, England, over a period of six years, but suggestive though these data are, much more of the same tenor is needed before the parallelism can be proved to be actually a causal one.

No feature in the natural history of the mackerel has attracted more attention than its habit of gathering in dense schools. It is not known how long these schools hold together, but the general opinion of fishermen is that they do so throughout the migrations at least, and although the mackerel may scatter and the schools mix more or less, especially when they are feeding on the larger and more active members of the free-floating fauna, as is said to be the case in British waters, they usually run very even in size. As a rule mackerel school by themselves. At times, however, they are found mingled with herring, alewives, or shad, as Kendall (1910, p. 287) has described. How the mackerel hold together, whether by sight or by some other sense, is yet to be learned, and various explanations have been proposed to account for the schooling habit, such as that it is advantageous for feeding, that it is a concomitant of spawning (this would not explain its persistence out of the spawning season, however, or the fact that even at spawning time any given school is apt to contain green and spent as well as ripe fish), or that it affords protection from enemies (which is just the reverse from the truth); but when all is said the instinct prompting it remains so mysterious that we can classify it no better than as a sort of sociability such as prompts so many species of birds to gather in flocks.

Autumnal migration.—As autumn draws on the fish that summer along the coast of Maine evidently work back toward Cape Cod, and of old, good fishing was had successively off Portland, near Boon Island, and off Cape Ann. Some time in September or October, in good years, the large mackerel reappear in abundance in Massachusetts Bay, and on many occasions schools have been reported and actually followed swimming on the surface southward across the mouth of the Bay

[35] Bullen. Journal, Marine Biological Association of the United Kingdom, Vol. VIII, New Series, No. 3, Oct., 1908, p. 269, 302. Plymouth.

[36] Allen, Ibid, p. 394–406.

at this time. Such accounts, it is true, are often based on a misconception,[37] but the fact that the latest catches of mackerel for the season are usually made thereabouts, along the outer shore of Cape Cod, or on the eastern side of Nantucket Shoals, and *never* in the inner parts of the Gulf of Maine, corroborate them in this instance. So much evidence of this sort has been gathered that we may accept as correct the view held by most fishermen that most of the mackerel desert the Gulf altogether in winter. It is not known, however, whether the schools entering on the Nova Scotian side go out again by the same route, or whether they join the general movement westward and then southward past Cape Cod. Mackerel usually remain in the Gulf of Maine into November, large catches sometimes being made about Cape Ann [38] late in the month, and occasionally, even, until mid-December, although this is unusual. In 1913, for example, 1,200 fish were caught off Gloucester on December 10; 3,000 off Chatham a day or two earlier; and in 1922 nearly 1,000 barrels were taken on the Massachusetts coast during the early part of the month. In mild winters mackerel are sometimes reported off the outer coast of Nova Scotia as late as Christmas time, but the last of December, at the latest, sees them vanish from the whole American seaboard.

Winter home.—The exact winter home of the American mackerel has not been found. True, a few have been caught on cod lines in deep water off Grand Manan in winter; [39] some found then near Yarmouth, Nova Scotia; others (all small) were taken from cod stomachs on Georges and La Have Banks and off the coast of New Jersey [40] at that season. There is at least one record of mackerel caught in a herring gill net in January many years ago. Otter trawlers, too, occasionally pick up a few on Georges Bank and in the South Channel in February or March. In 1922, for example, one otter trawler took a number of 1-pound fish in the Channel in 70 to 80 fathoms on February 27. Another vessel brought in 150 pounds of mackerel from the same ground on March 29, while other trawlers reported catching a few stray mackerel at about that time.[41] Such events happen rarely, however, and the numbers of fish concerned have always been too small to point to any of the usual fishing banks as the regular wintering grounds for mackerel. In fact no large bodies of the latter have ever been encountered anywhere off the American coast between the end of December and some time in March.[42] It is, however, reasonable to assume as a working hypothesis that the winter habits of the American fish parallel those of its North Sea relatives, which move out on the bottom from shallow waters generally, some to winter on bottom in the northern part of the North Sea, as proven by the trawl fishery, others (probably fewer) in the English

[37] The successive approach of one school after another to the coast often suggests a long-shore movement of the fish. Kendall (1910, p. 287), for example, tells of an instance when seiners reported "following" the schools continuously along southern Nova Scotia, although the fish taken off Liverpool proved to be of quite different sizes from the catch made about Cape Breton.

[38] In 1922 (Gloucester Times of Apr 26, 1923) the mackerel-netters fishing in that region did well all through November, taking something like 6,600 barrels during the month.

[39] Collins, 1883b, p. 273.

[40] Most recently on February 22, 1922, when a haddock fisherman took some from cod caught on the northwestern part of Georges Bank (Gloucester Times for Apr 26, 1923).

[41] Gloucester Times, Apr. 26, 1923.

[42] Schools of "mackerel" have been reported more than once in midwinter, but never supported by the actual capture of the fish.

Channel, but most of them, as appears from the statistics of the fishery, to go still farther out, probably to the outer edge of the continental shelf off Ireland to pass the cold season in deeper water.[43]

On this basis we might expect the Gulf of Maine mackerel to winter on the upper part of the continental slope at a depth rather greater than the otter trawlers reach—say at 100 to 200 fathoms—but so close at hand that odd fish stray or remain on the banks. Two facts strongly support the view that they go no farther than this in their offshore migration. First, no mackerel, young or old, have ever been taken far outside the continental shelf by the various deep-sea exploring expeditions of the past half century, or for that matter anywhere on the high seas far from land, nor more than a few miles south of Cape Hatteras off the American coast. Second, their reappearance takes place so nearly simultaneously in spring along many hundred miles of coast line that they can hardly have come from any great distance. It may be that some mackerel regularly winter in the deep basin of the Gulf of Maine itself. The winter catches listed above do, in fact, suggest that such is the case, and while as yet no direct evidence has been obtained that this applies to any considerable body of fish, the ground in question offers an attractive field for investigation with the otter trawl with an eye to the possibility of developing a winter fishery for mackerel. Thus time and increased knowledge have corroborated the views of Captain Atwood and of Perley, of more than half a century ago, that mackerel winter offshore in deep water and northward from the latitude of Virginia, not in the far south nor out in the surface waters of the warm parts of the Atlantic.

It has often been argued that mackerel hibernate. We even have the positive story of an "eyewitness" of high rank—an admiral, no less—of thousands so reposing in the mud in the Bays of Greenland with tails protruding—wholly an imaginary tale, we need hardly add.[44] Equally baseless, too, is the oft-repeated assertion that the adipose eyelid becomes opaque, so predisposing to hibernation in winter. European mackerel *may* sometimes hibernate. Ehrenbaum,[45] whose studies of this fish certainly entitle his views to great weight, thinks they probably do so for part of their stay on the bottom. It is not likely, however, that the American mackerel do so, though they may be semi-torpid or at least very sluggish during the cold season, the presence of mackerel in the stomachs of other fish (p. 196), as well as the fact that they sometimes have food in their own stomachs in midwinter, proving that they move about more or less even then, though they certainly feed very little, for not only are most of the European fish trawled at that season empty, but European and American mackerel alike are thin when they reappear in spring.

Most American students have looked on the rising temperature of spring as determining the date when mackerel quit their winter quarters, an event to be looked for as soon as the water warms to about 45°. Recent European studies, however, show that the date of reappearance is not as closely associated with temperature as has been supposed; and if it be true, as we believe, that the mackerel winter

[43] Ehrenbaum (Rapports et Procès-Verbaux, Conséil Permanent International pour l'Exploration de la Mer, Vol. XVIII, 1914) summarizes what is known of the life history of the European mackerel.

[44] Mackerel are not known so far north.

[45] Rapports et Procès-Verbaux, Conséil Permanent International pour l'Exploration de la Mer, Vol. XVIII, 1914.

on the bottom on the continental slope, vernal changes in the temperature of the surface water would be quite outside their ken. In short, the precise stimulus causing them to rise to the surface then is still to be learned.

Fluctuations in abundance.—It has been a matter of common knowledge since early colonial days that mackerel fluctuate widely in abundance from year to year—perhaps more so than any of the other important food fishes—periods of great abundance alternating with terms of scarcity or almost total absence, a serious matter for the fishermen. During good years the fish may appear in numbers almost unbelievable—schools or associations of schools, miles in length, are reported. It is common to see 50 or more separate bodies of fish from the masthead at one time. Mackerel, in short, seem to be everywhere, and a tremendous catch is made; but perhaps the very next year, and for no apparent reason, only an odd school will be found here and there and the fishery is a flat failure.

Looking back over the published statistics we see that from 1825 to 1835 was a period of abundance. In 1831, for example, more than 380,000 barrels (76,000,000 pounds) of salt mackerel (in those days most of them were salted) were landed in Massachusetts ports alone. Then for the next eight years (1837–1845) mackerel were scarce, only 50,000 barrels being landed in Massachusetts in 1840. From 1851, when the Massachusetts landings rose once more to 348,000 barrels, down to 1879, the annual catch fluctuated violently; but the year 1880, when the fleet brought in something like 294,000,000 fish from Nova Scotian and United States waters combined, saw the inception of a period of extraordinary abundance, culminating in 1885 when the catch reached the enormous total of 500,000 barrels (100,000,000 pounds). This was followed by a decline so extreme, so widespread, and so calamitous to the fishing interests that when the stock of mackerel reached its lowest ebb in 1910 the catch of the American mackerel fleet was only about 3,400 barrels (equivalent to 582,800 pounds of fresh fish) for the entire coast of the United States, with almost no mackerel, large or small, reported in Massachusetts Bay or along the Maine coast. As previous experience suggested, however, mackerel then increased once more in numbers, as appears from the annual catches made in the Gulf of Maine and on the banks at its mouth.

Year	Pounds [46]
1910	574, 092
1911	2, 478, 331
1912	4, 366, 906
1913	4, 777, 442
1914	7, 506, 875
1915	11, 106, 095
1916	16, 391, 377
1917	16, 021, 619
1919	2, 344, 552
1920 [47]	5, 608, 157
1921	1, 029, 002
1922	3, 048, 071
1923	11, 007, 676

[46] Salt mackerel are here reduced to the equivalent weight of fresh fish; no data are available for 1918.

[47] The southern fishery reported a good catch in 1920, which was not reflected either in the Gulf of Maine or in Nova Scotian waters.

However, this period of multiplication fell far short of equaling the period from 1883 to 1885, for the largest catches since the barren years about 1910 were but a fraction of those of the banner years in the eighties. After 1917 the stock once more diminished to such an extent that the catch for 1919 was only about 25 per cent of that of either of the two preceding years. Although 1920 saw a slight recovery, 1921 proved the worst season in the Gulf of Maine region since 1910. That summer, however, must have been an unusually favorable one for the production of young fish, as little mackerel 4 to 6 inches long appeared in great numbers in the Massachusetts Bay region the following June (1922), swarming in its various estuaries and locally as far north as Mount Desert Island, and raising the catch to slightly more than 3,000,000 pounds throughout the summer, growing meantime to a length of from 7 to 9 inches (p. 205). Their continued growth was probably responsible for the much larger catch in 1923.

Various far-fetched explanations for these astounding ups and downs in the mackerel catch have been proposed, such as that the fish have gone across to Europe, have sunk, or have been driven away or killed off by the use of the purse seine. However, since similar fluctuations were noticed long before the fishing became intensive, it is safe to say that they are quite independent of the acts of man but bound up with the biology of the fish. There is no reason to doubt that the major fluctuations in the annual catch do actually mirror corresponding changes in the numerical strength of the stock of fish existing in the sea from year to year, just as the annual catches of herring do along the North European coasts.

In the case of herring the prime factor in determining the abundance of the fish is now known to be the comparative success of reproduction from year to year, years favorable to the survival of the larvæ presaging several seasons of abundance, and vice versa. A comparison of the relative proportions of mackerel of different sizes (that is, ages) with the total catches made from year to year, justifies the working hypothesis that this is equally true of the mackerel.

About 1910, when the stock of mackerel was at its lowest (fig. 93), most of the fish caught were reported to be large, suggesting that few young had survived for several years past. Unfortunately no information is available as to the composition of the catch from the point of view of size for the next three years, when the catch was progressively somewhat larger, but numbers of very small fish, apparently yearlings, were reported in 1912. In 1914 we find fish smaller than 1½ pounds forming nearly 60 per cent of the catch made by the purse-seining vessels in and off the Gulf of Maine, with only about 4 per cent consisting of the large old fish (upward of 2¼ pounds); and in 1915 small fish formed approximately 80 per cent and large ones only 7 per cent, by weight, of all the mackerel caught in and off the Gulf of Maine, with an even greater preponderence of the former in actual numbers.

An alteration of this sort in the composition of the stock of any fish, from a predominance of large to a predominance of small, when it accompanies a decided increase in the total weight—still more in the total number—of fish caught, as was the case on the occasion in question, points beyond dispute to an increasing rate of production of young fish, sufficient to much more than offset the annual death rate. As suggested above, 1911 was the first good breeding year in this particular cycle,

accounting for the young "tinkers" reported in 1912. The years 1913 and 1914 must have been still more productive to produce the great preponderance of the "small" class in 1914 and 1915; and 1914 may also have been a good breeding season, for with so loose a classification (no subdivision of the fish smaller than 1½ pounds) it is impossible to tell how many fish become marketable in their second summer and how many not until their third summer. The total catch was more than 50 per cent greater in weight in 1916 than in 1915, but this increase was due chiefly to the graduation of fish that were "small" in 1915 into the "medium" and "large" classes, which together increased from about 14 per cent of the total weight caught in 1915 to about 80 per cent in 1916, and which probably dominated the catch in actual numbers as well, while the "small" fish formed less than 20 per cent by weight.

Small fish were again more abundant in 1917 than in 1916, both by weight (34 per cent of the catch) and probably in numbers, pointing to a very considerable production either in 1915 or in 1916, whichever of these two-year classes was concerned; but for several years thereafter breeding was so unsuccessful that the number of mackerel in such part of the stock as is tapped by the Gulf of Maine fishery dwindled from year to year as the year classes produced during the period 1912 to 1914 died out from one cause or another, without a sufficient production of young to compensate for the death rate, resulting in the great decline in the fishery noted above (p. 199), though enough young survived to keep the relative proportions of large and small fish about constant until 1919. Either in 1918 or in 1919 reproduction must have been close to a total failure, for the mackerel caught in and off the Gulf of Maine in 1920 ran very large, with small fish composing hardly 6 per cent (by weight) and large fish more than 60 per cent of the catch. The mackerel caught south of New York during that spring likewise averaged about 2 pounds in weight.

As regards its composition, the stock was now back again in about the same state as in 1910, the cycle having run over a period of 10 years. The parallel goes still further, too, for while no precise data as to sizes of the mackerel are available for 1921, that year must have seen a wave of production comparable to the successful breeding of the period of 1911-1914 to account for the swarms of yearling fish that appeared along the New England coast from Woods Hole to Mount Desert during the summer of 1922. Past experience would suggest that this presaged a great increase in the catch of mackerel for the next few years to come, as these little fish grow into the medium and large classes; and so it proved, for in 1923 over 11,000,000 pounds were taken in the Gulf of Maine region alone, and more than 8,000,000 pounds of this catch close alongshore.

Thus it seems that the proportion of large and small fish and the size of the catch for any one year may be used as a basis for predicting the success or failure of the run of mackerel in the following year. There may also be several good breeding years in succession, but history also teaches that after the fish of the 1921 year class and of the next two or three following (should there be more than one year of great production), pass their zenith and begin to drop out we must once more look forward to a shrinkage in the stock of mackerel and to poor fishing, for as far back as the record runs a good breeding year or a succession of such has been rather a rare event.

Nothing definite is known as to what determines the success or failure of reproduction of mackerel in any given year, nor what is the most vulnerable, hence critical, stage. It is obvious that there are two major factors concerned. It may be either a question of the number of eggs spawned and of their vitality, which harks back to the physiological condition of the parent fish, or may depend upon the success of the larvæ in surviving the dangers and difficulties of subsistence that confront them. Onslaughts by enemies, abundance and ready availability of food, temperature, salinity, density, and perhaps other physical and chemical conditions of the sea water (e. g., its alkalinity) all react upon the young fish. It may well be that a favorable environment depends on such a happy combination of all these that it is necessarily a rare event. Study of the composition of the stock of fish in periods of high and low production also suggests that there is a very definite correlation between the number of adult mackerel existing in the sea at any time and the success with which they breed, years of great production always falling when fish are both scarce and average very large and when, by general report, they are very fat.

We believe this justifies the working hypothesis that when there are few mackerel in the sea they grow fast, go into the winter in excellent condition, and hence are able to produce eggs of high vitality and in abundance; but when the fish are very plentiful they so deplete the food supply that individually they do not fare as well during the feeding period of late summer and autumn. Hence they neither grow as fast nor emerge from their winter quarters in as good physiological condition in spring, and under such circumstances they do not produce as many eggs per female, fertilization is less successful, and such larvæ as hatch are not as strong.

Food.—We may assume that the diet of the young mackerel is at first much the same in the Gulf of Maine as in the English Channel,[48] namely, copepod larvæ and eggs, the smaller adult copepods, and various other minute pelagic Crustacea and small fish larvæ. As the young fish grow they depend more and more upon larger prey. Our Gulf of Maine mackerel have repeatedly been seen packed full of Calanus, the "red feed" or "cayenne" of fishermen, as well as with other copepods, so often, indeed (we have examined many in this state), that it would be tedious to quote individual cases. They also feed as greedily on euphausiid shrimps, as do herring (p. 103), especially in the northeastern part of the Gulf where these crustaceans come to the surface in abundance. Various other planktonic animals also enter regularly into the dietary of the mackerel. Thus, Doctor Kendall writes in his field notes that in August, 1896, he found some of the fish caught on the northern part of Georges Bank packed with crab larvæ, others full of Sagittæ, others, again, of Sagittæ and amphipods (Euthemisto), of small copepods (Temora), or of "red feed" (Calanus), so that even fish of one school had selected the various members of the drifting community in varying proportion. Similarly, 1,000 mackerel caught near Woods Hole from June to August contained pelagic amphipods (Euthemisto), copepods, squid, and launce;[49] others taken off No Man's

[48] Lebour (Journal, Marine Biological Association of the United Kingdom, Vol. XII, New Series, No. 2, 1920, p. 305) gives diet lists for 90 larval mackerel ranging from 5 to 13.5 mm. in length, taken in the English Channel.

[49] Nilsson (Publications de Circonstance, Conséil Permanent International pour l'Exploration de la Mer, No. 69, 1914) gives a similar list for Swedish waters.

Land have been found full of shelled pteropods (Limacina); and a large series of small fish examined by Vinal Edwards contained copepods, shrimps, crustacean and molluscan larvæ, annelids, appendicularians, squid, fish eggs, and fish fry such as herring, silversides, and launce. In short, practically all the larger floating animals except the Medusæ and ctenophores regularly serve for the nourishment of mackerel, and a diet list for any given locality would include all the local pelagic Crustacea and their larvæ, Sagittæ, pteropods, etc.

In Swedish waters mackerel feed to a considerable extent on the younger stages of prawns (Pandalus and Pasiphæa) though we have no record of this in the Gulf of Maine. They have often been seen to bite the centers out of large Medusæ, but, as Nilsson suggests, they probably do this for the amphipods (Hyperia) that live commensal within the cavities of the jellyfish, not for the sake of the latter. Side by side with these comparatively large objects mackerel are also known to take various microscopic organisms, chiefly the commoner peridinians and diatoms, but they never feed extensively on these as menhaden do (p. 123). Mackerel also eat all kinds of small fish, to a greater or less extent according to circumstances. In the Gulf of Maine they devour large numbers of small herring, launce, and even smaller mackerel. They likewise feed on pelagic fish eggs when available, oftenest on those of their own species.

In the British Channel, according to Allen,[50] mackerel turn more and more to a fish diet as the summer and autumn advance and the young fry of the herring tribe become more and more abundant. This does not apply to the Gulf of Maine, however, where they have been found feeding more often on pelagic Crustacea than on fish throughout the season, nor, says Nilsson, to Swedish waters. Probably, the extent to which mackerel feed on fish depends entirely on the local supply. Nevertheless, while it can not be said that the mackerel feeds more on fish or on any other given prey at one time of year than another over its whole range, it is fully established that its diet varies from month to month, as is indeed inevitable because of the seasonal variations in the pelagic communities both of plants and of animals in all northern seas. No precise observations have yet been made on this phase of the diet of the mackerel of the Gulf of Maine.

Mackerel caught in the English Channel and examined by Bullen had fed indiscriminately (by filtration) and largely on unicellular plants in March, but more and more on animals, and, it seems, by selection as the spring progressed. Copepods are so plentiful in the Gulf of Maine, and the vegetable plankton swarming in April has so largely disappeared over most of the Gulf of Maine before the mackerel appear in spring, that we doubt if they are ever reduced to a vegetable diet there or, for that matter, anywhere in American waters.

Mackerel are also known to feed on bottom animals to a small extent. Nilsson, for example, reports various worms and hydroids and even small stones from their stomachs, but all experience in the Gulf of Maine is to the effect that this would be quite exceptional there, if it happens at all.

[50] Journal, Marine Biological Association of the United Kingdom, Vol. V, New Series, 1897, pp. 1–40. Plymouth.

It would be very interesting to test by histologic examination Bullen's observation that the kind of diet influences the anatomic condition of the walls of the stomach of the mackerel, these being very thick and contracted while the fish are feeding chiefly on vegetable food and thin and distensible while they are feeding on animal food. Until this subject is studied afresh we can only say that Bullen's note stands alone.

Most authors describe the mackerel as feeding by two methods—either filtering out the smaller pelagic organisms from the water by the gill rakers or selecting the individual animals by sight—but as the branchial sieve of the mackerel, which has long rakers on the foremost gill arch only, is not fine enough to retain the smallest organisms these mostly escape by passing through, just as copepods escape most of the whalebone whales. A good deal of discussion has centered about the relative serviceability to the mackerel of these two methods of feeding. Probably the truth is that when forced to subsist on the smallest articles in its dietary it must do so by sifting them out of the water, but that whenever opportunity offers to exercise its sight it selects the more desirable. This is a question of size, nor is it yet known how small objects the fish is able to pick out. Fish, of course, and such large Crustacea as euphausiid shrimps and amphipods it takes individually, just as the herring does. Judging from the fact that mackerel stomachs are often full of Calanus or of one or two other sorts of food in localities where indiscriminate feeding would yield them a variety, it is evident that this also applies to the larger copepods. Whether they select the smaller copepods and crustacean larvæ is not so clear. Captain Damant,[51] whose experience in deep-sea diving has given him an exceptional opportunity to observe mackerel feeding under natural conditions, describes fish among which he was at work as congregating about some 20 to 40 feet below the ship anchored in Lough Swilly (Ireland) and "feeding on plankton, not by steadily pumping the water through the gill filters but snatching gulps from different directions * * * and making little jumps here and there."

It has been a commonplace from the earliest days of the mackerel fishery that the fish, fat when last seen in the autumn, are very thin when they reappear in spring, obviously suggesting that they feed little during the winter, which is corroborated by the fact that the mackerel taken on bottom by British and French trawlers between December and March are almost invariably empty. A considerable body of evidence has been gathered in European waters to the effect that such of the European fish as are old enough to breed continue to fast after coming in on the coast until they have spawned, when they commence feeding greedily. In general the results of the American fishery, while it was carried on by hook and line, corroborated this for the June spawning schools of the Massachusetts Bay region. But it is certain in American waters that schools that are destined to spawn late in the season feed until the actual ripening of their sexual products commences, for in the Gulf of St. Lawrence, where spawning takes place in July, large catches of the maturing fish were regularly made in June—in fact, until the eggs began to run. These large mackerel would not bite thereafter until they were spawned out, which happens by the last half of July or first part of August.

[51] Nature, Vol. CVIII, Sept.-Dec., 1921, pp. 12-13. London.

It is a question whether the ripe males fast as rigorously while in breeding condition as do the females, for Cunningham [52] reports taking ripe ones in abundance on hook and line, but no females, at a locality where gill nets were yielding ripe fish of both sexes. The immature fish feed from the time they appear in spring, and the spent fish, very thin from their effort of breeding, at once commence eating and putting on fat, until by autumn they are in the best of condition for the winter or for the table.

Enemies.—Due to its habit of schooling the mackerel falls easy prey to all the larger predaceous sea animals. Whales, porpoises, mackerel sharks, threshers, dogfish, tuna, bonito, and bluefish in particular take heavy toll. Cod often eat small mackerel, squid destroy great numbers of young fish less than 4 or 5 inches long, and when the schools are on the surface sea birds of various kinds follow and prey upon them. A considerable list of parasitic worms, both round and trematode, are known to infest the digestive tract of mackerel, but so far as actual recorded observation goes they seem more immune to dangers from sudden unfavorable changes in their environment than are the herring, for instance, for they are never known to be killed by cold and seldom strand.

Rate of growth.—Although mackerel often spawn in abundance in the Gulf of Maine practically nothing is known of the young fish there until they are about 2 inches long. In North European waters mackerel grow to a length of about three-fourths of an inch within a few weeks after hatching, and numbers of larvæ up to this size have been taken about the spawning areas on both sides of the Atlantic. Small mackerel intermediate between these and fry of 2 to 3 inches have seldom been seen, but the latter have been taken repeatedly at many localities, chiefly in July and August, and as they are the smallest sizes so far reported for the late summer they probably represent the hatch of the previous May—that is, they are about 3 months old. In October and November young mackerel of 5½ to 8 inches are taken in abundance in Swedish and British waters, but it is not clear whether these are all the product of that year's hatch, the smaller representing the latest and the larger the earliest spawnings, or whether two year classes are concerned.[53]

Such notes as have been made on the sizes of American mackerel at different seasons correspond to what has just been outlined for the European fish. Thus Captain Atwood found fry of 2 inches or shorter in the Massachusetts Bay region in July, about a month after the local schools, assumed to be their parents, had spawned out, and we have seen mackerel of 1½ to 2½ inches, obviously spawned that spring, taken at Woods Hole during the first half of June. Others of 2½ to 3 inches have been reported there in July,[54] and fry of 2⅓ to 3¾ inches along the New York coast during that same month.[55]

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[52] Journal, Marine Biological Association of the United Kingdom, Vol. II, No. III, 1892, p. 232.

[53] Nilsson's studies (Conséil Permanent International pour l'Exploration de la Mer, Publications de Circonstance No. 69, 1914) led him to the former view, but mackerel scales are so difficult to read that this requires confirmation.

[54] Sherwood and Edwards, 1902.

[55] Bean (The food and game fishes of New York, 1903) also records fry of 3¼ to 3¾ inches from Long Island as early as May 23, 1906, but since mackerel do not commence spawning there until that month it is hard to account for them.

In the Gulf of Maine June-hatched larvæ probably grow to about 3½ to 4½ inches by the end of the summer, fry of that size (obviously of the same season's crop because too small for yearlings) having been taken at Gloucester in August. It is thought they will average about 4 to 6 inches in autumn. This is a smaller size than they are usually credited with. Captain Atwood, for instance, describes them as 6½ to 7 inches long in October, and there may be considerable variation in the length attained by the first winter according as particular lots of eggs are spawned early or late, and to the supply of food. But however this may be, fish of 4½ to 7 inches, which can only be yearlings (too small to be older and too large to be younger), and known locally as "tacks," are plentiful along the coasts of Massachusetts and Maine in May and June in the occasional years when there is any abundance of small mackerel.

The subsequent rate of growth has not been traced in as satisfactory a way for the mackerel as for some other fish, neither its scales nor its otoliths being as easy to read as those of salmon, herring, cod, etc. It is generally believed, however, that the yearlings grow to a length of 8½ to 11 inches during their second summer, which is corroborated by the fact that the small ones brought in to the Gloucester freezer during the season of 1922 averaged only about 6 inches long when they first appeared on the coast in May or June, but grew to from 7 to 9 inches by the end of August[56] and were said to average about one-third of a pound to half a pound in weight when they left the coast in autumn. Nilsson's scale studies point to 8½ to 12 inches as an average for Swedish mackerel in their second year,[57] suggesting a somewhat more rapid growth for the European fish, but the data are not sufficiently extensive nor precise for the American stock to show whether such a difference is really characteristic of the two sides of the Atlantic. It is probable that all American mackerel of 13 inches or longer are in their third summer or older. Their later growth has not been traced. Presumably they parallel their European relatives, which, according to measurements of large samples combined with examination of scales and otoliths,[58] average about 12½ inches in the third summer, 13 inches the fourth, 13½ inches the fifth, and anywhere from 13½ to 15 inches in their sixth summer, slight departures from which schedule are to be expected on the part of the American fish due to differences in food supply, length of growing season, etc. These European data suggest that our largest mackerel (16 to 18 inches long) have lived through at least five full years, probably six, and possibly seven or eight. Thus the growth of mackerel is very rapid for the first two or three years and very slow thereafter. This slowing down is probably a corollary of the ripening of the sexual products, breeding being so great a physiological strain that the fish do little more than recover before their winter stagnation sets in.

Age at maturity.—Some few females ripen when still not more than 11 inches long; most of them, and all males, at 12 to 13 inches. From this it seems that both American and European mackerel usually breed for the first time when 2 full years

[56] We owe this information to Captain Thomas, in charge of the freezer.

[57] He does not mention the exact seasons at which the fish were taken.

[58] Nilsson (Publications de Circonstance No. 69, Conséil Permanent International pour l'Exploration de la Mer, Vol. XVI, 1914, p. 26) and Ehrenbaum (Rapports et Procès-Verbaux, Conséil Permanent International pour l'Exploration de la Mer, Vol. XIV, 1912).

old and in their third May, June or July, depending on whether they are early or late spawners, but that some delay until a year older, should they have hatched late in the season or have grown slowly because of unfavorable surroundings of any sort. Once they have matured, no doubt they spawn annually throughout life as do other sea fish.

Proportions of the sexes.—In American waters males have usually been described as predominating largely over the females,[59] but as there seems no great disparity between the sexes off Sweden [60] this point calls for renewed study.

Breeding habits.—Mackerel spawn off the American coast from the latitude of Cape Hatteras to the Gulf of St. Lawrence; but although both ripe and spent fish have been reported from the southern spring fishery, and while mackerel have long been known to spawn regularly off southern New England, a much greater production of mackerel eggs takes place east and north than west and south of Cape Cod, with the Gulf of St. Lawrence far the most productive nursery for this fish. The scanty data yet available point to the Gulf of Maine as second to it in importance as a spawning ground, but whether mackerel spawn to any extent off the outer coast of Nova Scotia is still to be learned.

Spawning season.—Spawning mackerel have long been very familiar objects to the fishermen, the purse seiners often taking whole schools of fish in that state, and it is now well established that all mackerel that are old enough to breed are close to sexual maturity when they come to the surface in spring or early summer (according to locality).[61]

In the Gulf of Maine the first adult fish caught are usually still hard, but they are soon taken with the eggs or milt running. The last half of May and the month of June cover the height of the spawning season in the Massachusetts Bay region, though occasional ripe fish are taken there as late as the 1st of August. The mackerel spawn at about this same season off Casco Bay, where the largest run of spawning fish was about the middle of June in 1897, with the proportion of spent fish steadily increasing through July, which may be taken as descriptive of conditions over the Gulf of Maine as a whole. Our own mackerel-egg records are consistent with this, the earliest being for May 6, the richest in June as listed below, in tow net hauls at different localities during the spawning season in 1915:

Date	Station	Number of eggs taken	Date	Station	Number of eggs taken
May 6	10270	Few.	August 7	10304	2
May 20	10279	30+	August 10	Off Libby Island	10
June 14	10287	200+	August 11	do	20
June 19	10290	6	August 24	6 miles off Cape Ann	1
June 23	10291	25+	August 31	10306	3
July 7	10300	Few.	Do	10307	1
August 4	10303	50+	September 16	10318	1

[59] Smith. Report, U. S. Commissioner of Fish and Fisheries, 1900 (1901), p. 128.

[60] Nilsson. Publications de Circonstance No. 69, Conséil Permanent International pour l'Exploration de la Mer, Vol. XVI, 1914.

[61] J. P Moore (1899) gives observations on the sexual state of the fish caught off Casco Bay in 1897 and results of tow nettings for eggs.

In some years, however, spawning is not at its height until July (1882, for instance), and ripe fish are plentiful until August.

Any given school spawns over a considerable period, the fish as caught being in varying states—hard, running, or spent. So far as we can learn, however, mackerel have never been found spawning in autumn, though early in November of 1916 we towed a considerable number of eggs in Massachusetts Bay which so closely resembled mackerel eggs from the hatchery [62] (p. 208) that we would not have hesitated to identify them as such had they been taken in summer. They may have been the product of a belated fish, but probably of some other Scombroid.

In the Gulf of St. Lawrence the spawning season is at its height during the last half of June and the first two weeks of July, continuing into August, a fact well recognized by the hook-and-line fishermen of half a century ago, because the ripe fish will not bite at that time, and recently corroborated by the egg catches of the Canadian Fisheries Expedition.[63]

General experience is that ripe mackerel are to be expected wherever large catches are made in the appropriate season—in short, that its spawning range spreads both over the inner parts of the Gulf of Maine and over its offshore banks as well. Massachusetts Bay, in particular, is a prolific center of reproduction in good mackerel years, a fact long known and oft commented upon in print. There is abundant evidence, too, that in such seasons they breed very generally throughout the coastal zone outside the outer islands on the Scotian as well as on the New England side of the gulf, and few though our egg records are, they prove that mackerel spawn over deep basins as well as in the comparatively shoal coastwise waters to which the cod, haddock, and most flat fish repair for breeding. That Nantucket Shoals, Georges Bank, and Browns Bank, like the Scotian banks to the east, are also the sites of a great production of mackerel eggs is proven by the ripe fish caught there, but there is no reason to suppose that they ever breed outside the continental slope. On the other hand, they seldom spawn in estuarine situations, though known to do so on rare occasions. This probably applies even to Casco Bay, for although of old this was thought to be a favorable spawning ground, actual observations in 1897,[64] a year when mackerel were plentiful outside, proved that no eggs were being produced in the bay and that only rarely did any enter with onshore winds. Nor is it likely that mackerel breed successfully in the northern side of the Bay of Fundy, where neither eggs nor larvæ have been taken, but some production may take place near its mouth or on the Scotian side for Huntsman reports eggs at the mouth of the Annapolis River.

Mackerel, unlike cod or haddock, do not resort to any particular and circumscribed breeding grounds, but shed their eggs wherever their wandering habits have chanced to lead them when the sexual products ripen, and from this it follows that the precise localities of greatest egg production vary from year to year, depending on the local concentrations of the fish. Thus, the Gulf of Maine may see a tremen-

[62] The oil globule averaged very slightly larger—0.3 to 0.35 mm. as against 0.25 to 0.3 mm.

[63] Dannevig. Canadian Fisheries Expedition, 1914–15 (1919), p. 8.

[64] J. P. Moore, 1899.

dous production of mackerel eggs or practically none at all, corresponding to the fluctuations in the stock of fish, and this generalization applies equally to all other parts of the breeding range. In this respect conditions may vary widely in different regions in any given year. In 1915, for example (the only year when we towed consistently throughout the spawning season), small egg catches combined with a poor commercial catch of adult mackerel (p. 199) to suggest but little reproduction for the Gulf of Maine, but this must have been a very productive year in the Gulf of St. Lawrence, judging from the abundance of mackerel eggs the Canadian Fisheries Expedition found there.

Mackerel spawn over a wide range of temperature and, schooling and spawning near the surface as they often do, the eggs are produced in temperatures closer to those in which they are to develop than are the eggs of most ground fish. We have found odd eggs in the Gulf of Maine in water as cold as about 39° and as warm as 64°, while the Canadian Fisheries Expedition towed a few in temperatures as low as 38.8° and 40° off Halifax, but the chief production takes place between 46° and 61°. This applies equally to the Gulf of St. Lawrence where Dannevig records eggs in extremes of 42.6° and 61.7°, but where it seems they are produced in greatest number when the surface water is between 46.5° and 59°.[65] Mackerel spawn in the whole range of salinity proper to the open surface waters of the Gulf of Maine in summer, that is, from about 31.9 per cent to about 33 per cent, but never in brackish water.

The mackerel is a moderately prolific fish, females of medium size producing 360,000 to 450,000 eggs, but only a small part of these (40,000 to 50,000 on the average) are spawned at any one time (p. 207). Mackerel spawn chiefly at night.

The egg is buoyant, from 0.97 to 1.38 mm. in diameter, and with one large oil globule. A large series of Gulf of Maine eggs measured by Welsh were about 1.1 to 1.2 mm. in diameter with an oil globule of 0.3 mm. At a temperature of 60 to 62°, incubation occupies about 96 hours; about 120 hours at 55° in the hatchery. Newly hatched larvæ are 3.1 to 3.3 mm. long with very large yolk sac and numerous black pigment cells scattered over head, trunk, and oil globule. By the time the larva is 6 mm. long the yolk has been resorbed, the mouth is formed, and the teeth are to be seen. The eye is very large and the first traces of the caudal fin rays have formed. The rays of the second dorsal and anal fins and the ventrals appear at about 9 mm.; the first dorsal when the larva is about 14 to 15 mm. long. In fry of 22 mm. the dorsal and anal finlets are distinguishable as such and the tail has begun to assume the characteristic lunate form, but the head and eye are still much larger, the nose blunter, and the teeth longer than in the adult. At 50 mm. the little mackerel resemble their parents so closely that their identity as such is clearly apparent.

[65] Dannevig does not list the temperatures for the rich egg catches.

75. Chub mackerel (*Pneumatophorus colias* Gmelin) [66]

HARDHEAD; BULLSEYE; SPANISH MACKEREL

Jordan and Evermann (*Scomber colias*), 1896–1900, p. 866.

Description.—So closely does the "hardhead" (by which name it is commonly known to fishermen) resemble the common mackerel that we need mention only the points of difference. Most important of these, anatomically, is the fact that *P. colias* has a well-developed swim bladder connected with the esophagus, which the mackerel lacks; but it is not necessary to open the fish to identify it for there is a characteristic color difference between the two, mackerel being silvery-sided below the median line, whereas the lower sides of the hardhead—otherwise colored like the mackerel—are mottled with small dusky blotches. Less obvious differences are that the dorsal fins are closer together in the hardhead and that there are only 9 to 10 spines in its first dorsal fin instead of 11 or more, as in the mackerel.

Size.—This is a smaller fish than its better-known relative, growing to a length of about 8 to 14 inches only.

General range.—Temperate Atlantic Ocean, north to the Gulf of St. Lawrence,[67] and to England. It is represented in the Pacific by a close ally—*Pneumatophorus japonicus*.[68]

FIG. 94.—Chub mackerel (*Pneumatophorus colias*)

Occurrence in the Gulf of Maine.—Goode, et al. (1884), long ago summarized the peculiar history of the chub mackerel in our waters, which briefly is as follows:

It was tremendously abundant during the last of the eighteenth century and early years of the nineteenth century and down to 1820–1830, but it practically disappeared from the United States coast some time between 1840 and 1850. It is interesting to note, as Captain Atwood pointed out, that destructive methods of fishing had nothing to do with the case, since its disappearance antedated the introduction of traps, pounds, or purse seines, and similarly antedated the reappearance of the bluefish (p. 239), and hence can not be blamed on these sea pirates. So completely, indeed, did the hardheads vanish that for 10 years prior to 1879

[66] This genus is separated from Scomber by the possession of a well-developed swim bladder which the true mackerel lacks (see Starks, Science, new series, Vol. LIV, 1921, p. 223).

[67] Schmitt (Monographie de l'isle de Anticosti, 1904, p. 285, Paris) credits it with "apparitions irrégulières" at Anticosti.

[68] For the distinctions between the two see Starks (Copeia, No. 103, February, 1922, pp. 9–11).

the Smithsonian Institution tried in vain to secure a single specimen. In the summer of 1879, however, a school was taken in the weirs at Provincetown (where, as it chanced, representatives of the Bureau of Fisheries were stationed at the time), and although none were seen in 1880 the fish was not uncommon off the coast of New York in 1886. We find no definite record of its status during the next decade. In 1896, however, according to Bean (1903), it abounded along the shores of New York, running up little creeks in such numbers that it was dipped in boat loads. During that August [69] "hardheads" were taken singly and in schools by the mackerel fleet on Georges Bank, while many were caught on hook and line from the *Grampus* in Block Island Sound during the first week of September. In 1898 Kendall found it at Monomoy, the southerly elbow of Cape Cod, and it was then sufficiently reestablished for Smith (1898) to describe it as uncommon to abundant at Woods Hole. It then dropped out of the published record (it is not separated from the common mackerel in the fishery returns) until 1900, when it was found in the Casco Bay region. There is no reason to suppose that the fish appeared anywhere on our coasts in any numbers during the period 1898 to 1906, but in the latter year and again in 1908 an abundance was taken in the traps near Woods Hole, and in 1909 the mackerel fleet encountered great schools of hardheads on Georges Bank, vessels bringing in 50,000 to 100,000 each during the first week of July.[70] The fact that these were all small (500 to 700 to the barrel) suggests that there had been a great production of hardheads a year or two previous. Since that time fishermen speak of catching a few from time to time, but no great numbers.

The hardhead is distinctly a more southern fish than the mackerel, with the Gulf of Maine as its northern limit and Georges Bank apparently its eastern bound off the American coast. We find no record of it within the Gulf of Maine east of the neighborhood of Casco Bay, it being unknown in the Bay of Fundy, nor does it seem to reach the west Nova Scotian coast. In its rare years of plenty, however, it is apt to appear wherever mackerel do in Massachusetts Bay, especially about Provincetown, and Capt. E. E. Merchant, an old and observant fisherman, described them as so abundant from 1812 to 1820 that three men and a boy could catch 3,000 in a day on hook and line. The other definite Gulf of Maine records are mostly about Casco Bay.

Habits.—Hardheads school like mackerel, and their feeding habits are evidently the same, for Doctor Kendall found the fish on Georges Bank in August, 1896, full of the same species of pelagic Crustacea and Sagittæ as the mackerel had taken at the same time and place, while specimens taken at Woods Hole had dieted chiefly on copepods, to a less extent on amphipods, Salpæ, appendicularians, and young herring. They follow thrown bait as readily and bite quite as greedily as mackerel do. Its breeding habits have not been followed.

Commercial importance.—The chub mackerel is as choice a table fish as the mackerel, and no distinction, other than that of the size of the individual fish, is made between them in the market.

[69] Field notes supplied by Dr. W. C. Kendall

[70] Boston Herald, July 9, 1919.

76. Striped bonito (*Gymnosarda pelamis* Linnæus)

OCEANIC BONITO

Jordan and Evermann, 1896–1900, p. 868.

Description.—This bonito is separable at a glance from the mackerel by its much stouter and more robust form, it being one-fourth as deep as long, though similarly fusiform and tapering to pointed snout and slender caudal peduncle, and by the fact that its dorsal fins are practically contiguous. The concave outline of the first dorsal marks it off from the Spanish mackerel (p. 217), common bonito (p. 215), and tuna (p. 212), which resemble it in the close apposition of the two dorsals. More diagnostic, however, is the fact that the striped bonito has no body scales except for a very prominent "corselet" on the forward and upper part of the trunk, which is outlined in the illustration (fig. 95). The fact that the lateral line curves downward suddenly below the second dorsal separates it from its genus mate, the "little tunny" (*G. alleterata*), a fish to be expected, though not yet actually recorded, in the Gulf of Maine.

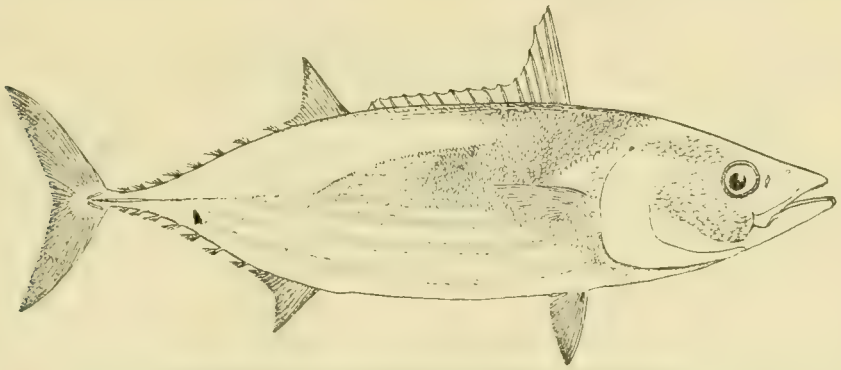

FIG. 95.—Striped bonito (*Gymnosarda pelamis*). After Schmidt

The first dorsal (about 15 spines) is not only much longer than that of the mackerel, but of rather diagnostic form, being abruptly concave behind the second spine with the last 9 or 10 spines much shorter. Almost the whole of the second dorsal, triangular in form but with concave rear margin, stands in front of the anal, which about equals it in size and is of similar outline. There are about 8 little finlets behind the second dorsal, and 7 behind the anal. The pectoral is of moderate size, reaching back only about midway of the first dorsal. The tail fin is very short but broad and lunate in outline, and there is a conspicuous median keel on either side of the caudal peduncle.

Color.—Deep steel blue above, with lower sides, throat, and belly shining white. Each side is barred behind the corselet with 4 to 6 longitudinal blue or brown stripes, the upper ones terminating at their intersection with the lateral line, the lower 3 or 4 fading out as they near the caudal peduncle.[71]

[71] The number of stripes is variable in different regions, for whereas American fish usually show 4 only, 7 have been described in Japanese specimens, while in the European bonito there are usually 4 and sometimes 5 or 6 on each side

Size.—This bonito grows to a length of about 30 inches.

General range.—Warmer parts of all the great oceans—Atlantic, Pacific, and Indian.

Occurrence in the Gulf of Maine.—A single specimen obtained at Provincetown in 1880 by J. Henry Blake is the only record for this oceanic fish in the Gulf. It sometimes appears in numbers about Woods Hole, where 2,000 to 3,000 were taken in 1878, but where it did not show again until October, 1905.[72]

77. **Tuna** (*Thunnus thynnus* Linnæus)

HORSE-MACKEREL; GREAT ALBACORE; TUNNY; ALBACORE

Jordan and Evermann, 1896–1900, p. 870.

Description.—The two dorsal fins of the tuna are practically continuous—a character, with the large number of finlets, sufficient in itself to separate a small one from the true mackerels. It is readily separable from the striped bonito and little tunny by the fact that the entire trunk, including the belly, is scaly, and from the

FIG. 96.—Tuna (*Thunnus thynnus*). After Schmidt

common bonito (p. 215) by the height and outline of its second dorsal and anal fins as well as by the small size of its jaw teeth, and by the fact that its vomer (on the midline of the roof of the mouth) is armed with hairlike teeth. The tuna is shaped like a bonito rather than a mackerel, with robust body, about one-fourth as deep and one-sixth as thick as long, tapering to pointed nose and very slender caudal peduncle which bears a strong median longitudinal keel on either side. The first dorsal (13 or 14 spines), originating just behind the axil of the pectoral, is triangular, tapering regularly backward from its first spine and with the last spine very short indeed. The second dorsal (about 13 rays) is almost confluent with the first—slightly lower than the latter in young and higher in old fish. It is much higher than long, falcate, deeply concave behind, and its angle sharp pointed. The anal originates under the rear end of the second dorsal to which it is similar in outline and size (about 12 rays). There are usually 9 or 10 dorsal and 8 or 9 ventral finlets

[72] The little tunny or bonito, *Gymnosarda alletcrata*, is much commoner in the Woods Hole region, appearing regularly in July and August, and is more apt to be caught in the Gulf of Maine than is the striped bonito, though not actually recorded there. It is separable from the latter by the fact that its lower sides are plain silver without the stripes of the striped bonito; that the hind part of its back is marked with wavy bands and spots, whereas in the latter it is plain; that its lateral line is not curved below the second dorsal; and that its anal fin originates farther back, under the first dorsal finlet.

behind the second dorsal and the anal fins. The tail fin is much broader than long, its margin deeply lunate, its two lobes sharp pointed, just as it is in the bonitos. The pectoral and ventral fins are of moderate size, the former scimitar-shaped and much longer than broad.

Color.—The back is dark lustrous steel blue or nearly black, with gray or green reflections; the cheeks silver; the sides and belly silvery gray, often with large silvery spots and bands, and iridescent with pink. The first dorsal is dusky to blackish; the second dusky to reddish brown; the dorsal finlets yellow with dark edgings. The anal fin is silvery gray; the anal finlets the same, or yellow; the caudal dusky but more or less silvery; the ventrals and pectorals blackish above and silvery gray below.[73]

Size.—This is the largest Gulf of Maine fish, except some sharks. It is said to reach a length of 14 feet or more, and a weight of 1,600 pounds,[74] with fish of 1,000 pounds not uncommon. But few of the largest have actually been weighed as taken from the water, and although monsters are not unheard of, the heaviest Rhode Island fish on record weighed only 750 pounds.[75] In the Mediterranean, where tuna are far more plentiful than in the Gulf of Maine but run smaller, a 500-pound fish is a giant, and this is equally true off the California coast.

General range.—Warmer parts of the Atlantic (including the Mediterranean) and Pacific; north to Newfoundland on the east coast of America.

Occurrence in the Gulf of Maine.—Although every fisherman knows the "horse mackerel," and although this great fish visits all parts of the Gulf of Maine, we know little more of its comings and goings there than when Storer called attention to its abundance about Provincetown three-quarters of a century ago. Rarity is not to blame for this—it is common enough—but the fact that little attention has been paid to it for want of market value. It is a yearly visitor to the Gulf, appearing in June and remaining throughout the summer, to disappear in October.

Food and habits.—Tuna prey on smaller fishes, particularly on menhaden and mackerel, of which they are often full. They also destroy great quantities of herring and have been known to swallow whole dogfish as large as 8 pounds. They feed, in fact, on all the smaller schooling fishes, the particular species depending on the local supply, and also on squid. It is not unusual for horse mackerel to strand—probably in pursuit of prey. Though so voracious the tuna is proverbially a timid fish and easily frightened. Like all its relatives it is a schooling fish, and due to its habit of leaping even a few are apt to be noticed.

The local distribution of tuna within the gulf is no doubt governed by that of the fish on which it preys. The entrance of Massachusetts Bay, on the Cape Cod side, has long been known as a resort of "horse mackerel,"[76] and from time to time tuna are seen all around the shores of the bay—for that matter along the whole western and northern coast line of the Gulf—and they have been recorded from various localities in Maine. The region centering at Casco Bay has been reported

[73] The foregoing description of the color is based on accounts of freshly caught tuna by Storer (1853–1867) and by Nichols (Copeia, No. 111, Oct. 20, 1922, pp. 73–74); and on fish we have ourselves seen.

[74] A fish of this size was reported in the Boston Transcript for July 20, 1923, as recently taken at Manasquan, N. J.

[75] Tracy, 1910, p. 103.

[76] Many years ago Captain Atwood spoke of seeing as many as 50 in a day there.

a favorable ground for horse mackerel, and they appear fairly regularly every summer along the Scotian side of the Bay of Fundy near its mouth; less often on the New Brunswick side. Tuna are also to be had off the west coast of Nova Scotia, and fishermen often report them on Georges and Browns Banks. Various bays on the south shore of Nova Scotia and about Cape Breton to the east, and the neighborhood of Block Island to the west of the limits of the Gulf, are well-known centers of abundance for these great fish every summer, where more are seen than anywhere in the Gulf of Maine. The following statistics of the catch of the shore fisheries for 1919 (a representative year) will illustrate the local distribution of tuna around the coast line of the Gulf:

	Number of pounds
Nova Scotia:	
Yarmouth County	20, 400
Digby County	4, 000
Maine:	
Cumberland County (neighborhood of Casco Bay)	4, 645
Hancock County	-----
Kennebec County	-----
Knox County	-----
Lincoln County	17, 300
Sagadahoc County	5, 875
Waldo County	-----
Washington County	-----
York County	-----
Massachusetts:	
Barnstable County (chiefly Cape Cod Bay)	37, 048
Essex County	5, 000
Plymouth County	-----
Total	94, 268

Assuming an average weight of 200 pounds (probably too little) this would be about 450 fish.

No definite information is available as to the annual fluctuations of the tuna, but fishermen are well aware that its local numbers in any part of the Gulf vary widely from year to year, and it is on record that tuna were scarce in Massachusetts Bay for two or three years prior to 1904, but so abundant during that summer that the market was glutted with them.

The fish that visit us are mostly large. We have never heard of a single young one of less than, say, 20 pounds, taken in the Gulf of Maine, but a small tuna might easily be confused with the common bonito and reported as such. Furthermore, although the Gulf of Maine tuna are of breeding age, no ripe fish have ever been seen off the New England or Canadian coasts.

The winter home of the tuna, which summer off eastern North America, is unknown. Probably they pass the cold season in deep water, as do the tuna of the Mediterranean, but whether they merely repair to the continental slope, or how much farther afield they wander into the Atlantic Basin, is still to be learned. We are equally in the dark as to whether the large fish seen in the Gulf and along the Nova Scotian coast are spent (having spawned in spring perhaps hundreds or

even thousands of miles away) and visit our waters on a feeding migration to fatten after the strain of reproduction, as is probably true of the swordfish (p. 225), or whether they actually spawn in our waters or near by, ripe fish having been overlooked there. In fact, nothing definite is known of the breeding of the tuna. In European waters it is *supposed* to spawn in summer. Presumably its eggs are pelagic, though never actually described, nor have its young fry been identified.

Growth is probably very rapid, for young of the year are said to weigh 30 ounces in October in European waters. However, no attempt has been made to determine the age of the large fish.

Commercial importance.—The tuna is highly prized as a food fish in the Mediterranean and in California. On the Atlantic coast, however, they have only recently been salable, and they were formerly regarded only as a nuisance, for bands of them make trouble for fishermen by following mackerel or herring into the weirs and pounds to tear their way out again right through the nets unless harpooned. It is recorded that 30 very large ones were killed in a day in one net near Gloucester. Many years ago, when fish oil was more valuable than now, a few were sometimes harpooned for oil, which was tried out of the heads and bellies, but there was no demand for the meat. Within the last few years, however, it has proved worth while to bring in the few accidentally caught rather than to leave them to rot. The Gulf has yet to see any organized tuna fishery, however, nor is it likely that this fish is there in sufficient abundance to support one.

The sporting possibilities of the tuna deserve a word, for anglers, spurred on by the wonderful tuna fishing on the southern coast of California, have attacked this huge fish with light tackle at various points in New England and Nova Scotia, and with considerable success, for the tuna bites freely on trolled bait of herring or other silvery fish. I have even known a Massachusetts Bay tuna to take a cod hook, going away with line and all, though it is unusual for them to bite a "dead" bait. Some of the smaller fish up to 125 pounds or so have been landed, particularly off Block Island and in the bays along the southeastern coast of Nova Scotia. A Dr. L. D. Mitchill landed one 10 feet 4 inches long and weighing 710 pounds at Port Medway, Nova Scotia,[77] but no one, we believe, has yet succeeded in subduing a really large tuna on rod and reel.

78. **Common bonito** (*Sarda sarda* Bloch)

BONITO; SKIPJACK; HORSE MACKEREL

Jordan and Evermann, 1896–1900, p. 872.

Description.—This bonito is shaped much like a small tuna, being thick and stout bodied, about one-fourth as deep as long (not counting caudal fin), and similarly tapering to pointed snout and slender caudal peduncle. It is tunalike, also, in that its body is scaled all over, its caudal peduncle bears median lateral keels, and its dorsal fins are so close together as to be practically confluent, but the shape of its fins distinguishes it at a glance from a small tuna, the only Gulf

[77] This record capture has been mentioned repeatedly in the sportsmen's journals, "Field and Stream" and "Forest and Stream."

of Maine fish with which it is apt to be confused,[78] its first dorsal being relatively much longer than that of the tuna (about one-third as long as the body, not counting the caudal, and with about 21 spines), and, what catches the eye more, its second dorsal is hardly more than half as high as the first and much longer than high, whereas in the tuna it is as high or higher than the first and much higher than long. Its mouth, too, is relatively larger than that of the tuna, gaping back as far as the hind margin of the eye, and its jaw teeth are larger, with the two to four in the front of the lower jaw noticeably larger than the rest.

We need only note further that its first dorsal is triangular, tapering regularly backward, its outline only slightly concave; that the margins of the second dorsal and anal are both deeply concave; that there are 7 or 8 dorsal and 7 anal finlets; that the tail fin is lunate, much broader than long; and that the lateral line, though wavy, is *not* deeply bowed below the second dorsal.

Color.—The color of this bonito is so distinctive as to afford a ready field mark to its identity, for while it is steely blue above with silvery lower side and abdomen, like most mackerels, its upper sides are barred with 7 to 20 narrow dark bluish

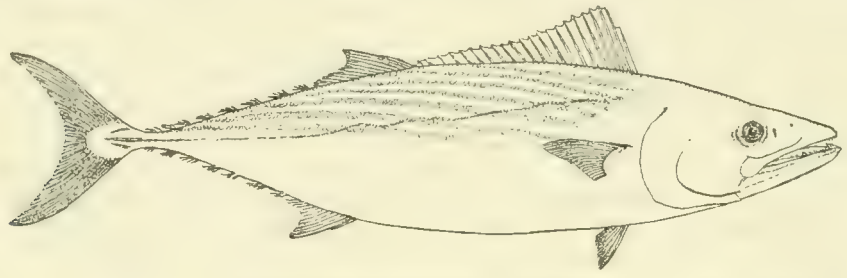

FIG. 97.—Bonito (*Sarda sarda*). After Schmidt

bands running obliquely downward and forward across the lateral line. While young the back is transversely barred with 10 to 12 dark blue stripes, but these dark bars usually disappear before maturity.

Size.—This bonito grows to a length of about 23 to 30 inches and a weight of 10 to 12 pounds.

General range.—Warmer parts of the Atlantic, including the Mediterranean; north to Maine on the American coast and to Scandinavia on the European coast.

Occurrence in the Gulf of Maine.—Cape Ann is the northern limit to the regular occurrence of the bonito, and while it has been taken occasionally in Casco Bay there is no definite record of it east of this on the coast of Maine, in the Bay of Fundy, or along the west coast of Nova Scotia, and this limitation to the southern half of the Gulf appears very clearly in the location of the commercial catches. In 1919, for example, pound nets, traps, etc., accounted for almost 34,000 pounds in Cape Cod Bay, but only 90 pounds about Cape Ann, while the entire catch landed in the fishing ports of Maine was only 4 or 5 fish (44 pounds). The catch was slightly less than this in 1889 (about 30,000 pounds), and in 1902 (11,200 pounds), say 100 to 300 fish yearly.[79] Bonito may have been more numerous in Massachu-

[78] No one should take a bonito for a large mackerel, its dorsal fins being close together, while those of the mackerel are far apart.

[79] The annual reports of the Massachusetts commissioners contain statistics of the catches in weirs, etc., by towns.

setts Bay during the seventies of the past century, however (a period of great plenty off southern New England), 73 having been taken in one day in August, 1876, in a weir near Gloucester, and probably they are far more plentiful out at sea in the southern part of the Gulf than these meager returns would suggest, as might be expected of an oceanic fish that comes inshore only in pursuit of prey, for fishermen often mention schools of them. In August, 1896, for instance, Capt. Solomon Jacobs reported them as very plentiful in the deep water to the northward of Georges Bank, and we ourselves have more than once seen schools of large Scombroids, probably bonito, off Cape Cod in August. The bonito is more regular in its occurrence west and south of the cape, being common at Woods Hole and especially off Marthas Vineyard, where 123,000 pounds were marketed in 1902.

Habits.—The bonito, like all its tribe, is a strong, swift, predaceous inhabitant of the open sea, traveling in schools, preying upon mackerel, alewives, menhaden, and other smaller fish such as launce and silversides, and also upon squid. They are very apt to be noticed, for they jump a great deal when in pursuit of their prey.

It is not likely that it ever spawns in the Gulf of Maine, nor does it in the northern part of its European range. For that matter, nothing is known of its spawning

FIG. 98.—Spanish mackerel (*Scomberomorus maculatus*)

habits anywhere, though presumably its eggs are buoyant like those of other Scombroids, nor has its rate of growth been studied.

Commercial importance.—The bonito is usually considered a good food fish. It readily bites a bait trolled from a moving boat and a good many are so caught off Block Island, but they are never abundant enough in the Gulf of Maine to be worth fishing for there with hook and line. In Massachusetts Bay the catch is practically all in pounds, etc., except for a few that are seined.

79. **Spanish mackerel** (*Scomberomorus maculatus* Mitchill)

Jordan and Evermann, 1896–1900, p. 874.

Description.—The Spanish mackerel has the outline of the slender mackerel rather than the stout bonito, its body being about 4½ to 5 times as long as deep. There is no danger of confusing it with either of the true mackerels—first, because its two dorsal fins, like those of the bonito, are hardly separated, and second, because of its color pattern. Its high second dorsal, slender form, and spotted sides, mark it off at first glance from our two bonitos, while its color, form, long first dorsal, and the outline of its second dorsal distinguish it from the tuna. The most obvious distinction between the "Spanish" and its close relative the "king" mackerel is that its ventrals are *behind* the origin of the first dorsal and that there are only 32 teeth, or fewer, in each jaw, and its color.

Its most distinctive anatomic character among our local Scombroids is its large conical jaw teeth, of which there are 16 above and 13 below on each side. The caudal peduncle is keeled; the lateral line wavy; the first dorsal fin (17 to 18 spines) triangular; the second dorsal (16 to 18 rays) concave and originating a short distance in *front* of the anal, which is similar to it in form and size. There are 8 or 9 dorsal and as many ventral finlets, and the caudal is deeply lunate, its outer rays decidedly longer than those of the mackerel.

Color.—The Spanish mackerel is dark bluish or blue green above, pale below, like all Scombroids, and silvery, its sides marked with many small oblong-oval, dull orange or yellowish spots, both above and below the lateral line, these being a very diagnostic character. The fact that the membrane of the front one-third of the first dorsal fin is black, whereas its rear part is white, is an equally useful field mark. The second dorsal and pectoral fins are pale yellowish and dusky edged; the anal and ventrals are white.

Size.—The maximum weight is about 9 or 10 pounds (one 25), and the length 36 inches, but the fish caught average less than 3 pounds.

General range.—Both coasts of North America, north to Maine and south to Brazil in the Atlantic.

FIG. 99.—King mackerel (*Scomberomorus regalis*)

Occurrence in the Gulf of Maine.—The Spanish mackerel is a regular summer visitor all along the Atlantic coast of the United States as far north as New York; less abundant along the southern coasts of New England, though a few are taken during most summers at Woods Hole; and only a stray in the colder waters of the Gulf of Maine, where odd fish are taken in Cape Cod Bay every year or two. In 1896 the local catch even rose to 37 fish (Provincetown and Truro traps), and there is record of it at Lynn, Mass., but north of this Spanish mackerel are so rare that Monhegan Island is the only record for Maine and the most northerly outpost for this species.

The Spanish mackerel is a schooling fish like other mackerels and preys upon smaller fishes of any kind, being hardly less destructive than the bluefish. On the southern Atlantic coast, where it supports an important fishery, it comes in from offshore or from the south—which, is not known—when the water warms to from 56° to 70°, appearing off the Carolinas in April, but not until July in New York waters. It disappears from the northern part of its range in October.

Habits.—Spanish mackerel, unlike oceanic bonitos, come close inshore to breed, Chesapeake Bay being one of their most prolific northern nurseries. They

certainly spawn as far north as Long Island, but there is no reason to suppose that they ever do so north of Cape Cod because their sexual products do not mature at temperatures lower than 70°. However, we may mention in passing that the spawning season extends from April in the Carolinas to September off New York, continuing 6 to 10 weeks in a given locality, with individual fish spawning over a considerable period; that the eggs are buoyant (0.91 to 1.14 mm. in diameter, with one large oil globule of about 0.23 mm.); that incubation occupies about 25 hours at 77° temperature; and that the newly hatched larvæ grow to 3.2 mm. in 20 hours. The later larval stages have not been described.[80]

80. **King mackerel** (*Scomberomorus regalis* Bloch)

KINGFISH; CERO

Jordan and Evermann, 1896–1900, p. 875.

Description.—In its general appearance the kingfish closely resembles the Spanish mackerel, but its ventrals are directly below instead of behind the origin of the first dorsal, its head is relatively longer, its nose more pointed, its teeth more numerous (about 40 in each jaw), triangular and very sharp pointed, and the upper half of the first dorsal is deep blue. Furthermore, the king mackerel is marked by a narrow brown stripe running from close behind each pectoral fin to the base of the caudal, crossing the lateral line as the latter bows downward below the second dorsal fin. Its side spots, too, are mostly below the lateral line and arranged in rows, whereas in the Spanish mackerel the spots are irregularly scattered and there are about as many above as below the lateral line.

Size.—Said to grow to a length of 4 or 5 feet and a weight of 20 to 35 pounds.

General range.—Atlantic coast of North America, Cape Cod to Brazil. Abundant in the West Indies.

Occurrence in the Gulf of Maine.—This southern fish has been recorded by Dr. W. C. Kendall at Monomoy, the southern elbow of Cape Cod. It has not been taken elsewhere in the Gulf of Maine.

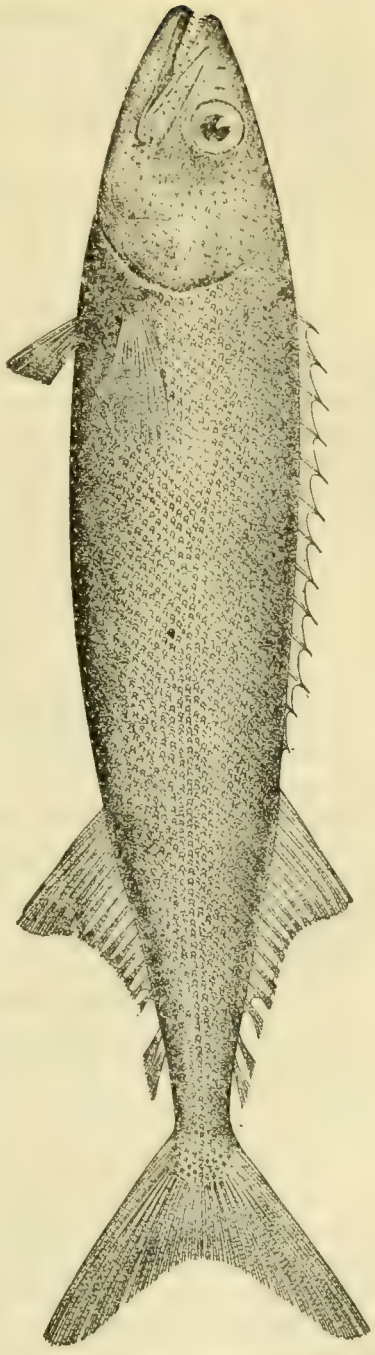

Fig. 100.—Escolar (*Ruvettus pretiosus*) ⅓

[80] Ryder (Bulletin, U. S. Fish Commission, Vol. I, 1881 (1882), p. 135) has given a detailed account of the early stages in development.

THE ESCOLARS. FAMILY GEMPYLIDÆ

These fishes are closely allied to the true mackerels, the most obvious differences being that they lack the keels on the sides of the caudal peduncle so characteristic of the mackerels.

81. Escolar (*Ruvettus pretiosus* Cocco)

OILFISH; SCOURFISH; PLAINTAIL

Jordan and Evermann, 1896–1900, p. 879.

Description.—In its elongate fusiform outline and in the general arrangement of its fins this fish suggests the mackerel family. Its first (spiny) dorsal (13 to 15 spines), like that of the Spanish mackerel, is much longer than the second dorsal (18 soft rays). It is separable at a glance from all Gulf of Maine mackerels by the fact that there are only 2 dorsal and 2 anal finlets and that the skin is set with bony plates with short spines instead of being velvety with small scales, as it is in the case of the mackerels. The caudal fin is deeply forked. The first dorsal is much lower than the second and the anal is situated below the second dorsal, which it parallels in its outlines.

Size.—It grows to a weight of at least 100 pounds.

Color.—Described as purplish brown, darkest above with blackish patches, and the inside of the mouth as dusky.

General range.—Tropical parts of the Atlantic and the Mediterranean in moderately deep water (usually 300 to 400 fathoms). It is plentiful about Cuba though not reported at Porto Rico, and has been known to stray as far north as the Grand Banks of Newfoundland. There is a regular fishery for it off Cuba and about the Canaries; also in the Pacific.

Occurrence in the Gulf of Maine.—Two escolars, respectively 49 inches and 6 feet long, were brought in to the United States Fish Commission from Georges Bank during the autumn of 1891.[81]

THE CUTLASSFISHES. FAMILY TRICHIURIDÆ

82. Cutlassfish (*Trichiurus lepturus* Linnæus)

HAIRTAIL; SCABBARDFISH; SILVER EEL; RIBBANDFISH

Jordan and Evermann, 1896–1900, p. 889.

Description.—The most striking characteristics of the cutlassfish are its bandlike form tapering to a pointed whiplike tail, without caudal fin, the single long low dorsal fin (about 135 rays) originating close behind the eye and diminishing to nothing some distance in front of the tip of the tail, and the long barbed fangs in the front of its mouth, four in the upper and two in the lower jaw. The head is about twice as long as the fish is deep, with pointed snout, mouth gaping back to below the eye, and lower jaw projecting beyond the upper. Each of the jaws is

[81] Approximate location 41° 40′ N., 67° 44′ W. See Goode and Bean, 1896, p. 197.

armed with 7 to 10 smaller teeth behind the fangs. The anal fin is reduced to a series of short inconspicuous spines, about 100 to 110 in number, without connecting fin membrane, running back from the vent nearly to the tip of the tail. The small pectorals are situated close behind the posterior angle of the gill cover. There are no ventral fins and the skin is scaleless.

Color.—Preserved examples are bright silvery all over. The dorsal fin has been variously described as yellowish or dusky green in life, dark edged or speckled along the margin with black.

Size.—Maximum length about 5 feet.

General range.—Warmer parts of the Atlantic; abundant in the West Indies; rarely straying north to Massachusetts Bay.

Occurrence in the Gulf of Maine.—The cutlasfish is only an accidental straggler north of Cape Cod. One was taken at Wellfleet in the summer of 1845, and one, also, in Salem Harbor many years ago. It is recorded from Lynn by Kendall.[82] There is no record of it farther north in the Gulf of Maine or in Canadian waters.

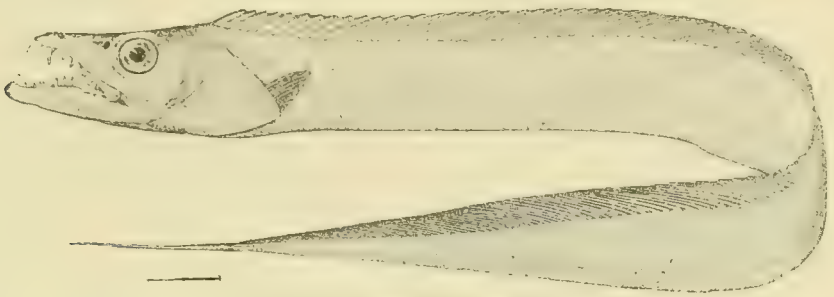

FIG. 101.—Cutlasfish (*Trichiurus lepturus*)

THE SWORDFISHES. FAMILY XIPHIIDÆ

The upper jaw and snout of the swordfish (there is only one species) is greatly prolonged, forming a flat, sharp-edged sword. There is a very high first dorsal fin and a very small second, both soft rayed; a broad lunate tail; two separate anal fins, the second being very small; and strong longitudinal keels on the caudal peduncle. There are no ventral fins, and in the adult there are neither teeth nor scales. The spearfish family is the only other group represented in the Gulf of Maine fauna which at all resembles the swordfish, but spearfish have ventral fins and teeth, their swords are round edged, and either there is one long continuous dorsal fin or, if there are two, the first is relatively several times as long as in the swordfish.

83. Swordfish (*Xiphias gladius* Linnæus)

Jordan and Evermann, 1896–1900, p. 894.

Description.—The salient feature of the swordfish is the prolongation of its upper jaw into a long, flattened, sharp-edged [83] and pointed "sword," occupying

[82] The Massachusetts Bay and Provincetown records listed by Kendall (1908) are based on the Wellfleet specimen. He also credits it to Monhegan Island, Maine, quoting Storer as his authority, but Storer expressly states in his latest mention of the species that but two had come to his notice—the Wellfleet specimen just mentioned, and one taken at the head of Buzzards Bay.

[83] In its tropical relatives, the sailfish and spearfish, the sword is round edged, spearlike, and relatively shorter.

nearly one-third the total length of the fish. This sword is of itself enough to identify the fish at a glance among all our northern fishes. In one 10 feet 10 inches long, which we killed on Georges Bank on the *Grampus* in July, 1916, the sword, tip to eye, was 42 inches long. The swordfish is moderately stout, only slightly compressed, deepest just behind the gill opening, and tapering rearward to a very slender caudal peduncle, which bears a single strong longitudinal keel on either side. Apart from the sword the head is short, the lower jaw pointed, and the mouth so wide that it gapes far back of the very large eye, which is set close to the base of the sword. Swordfish (except young fry) are both toothless and scaleless. There are two dorsal fins. The first originates over the upper angle of the gill opening and is much higher than long (about 39 to 40 rays), with deeply concave margin. The second is very small and set far back on the caudal peduncle. There are likewise two anals. The second is as small as the second dorsal and below it, while the first is similar to the first dorsal in outline but shorter, and located well behind it, close to the second. The pectorals are narrow, very long, falcate, and set very low down on the sides below the first dorsal. The caudal fin is short,

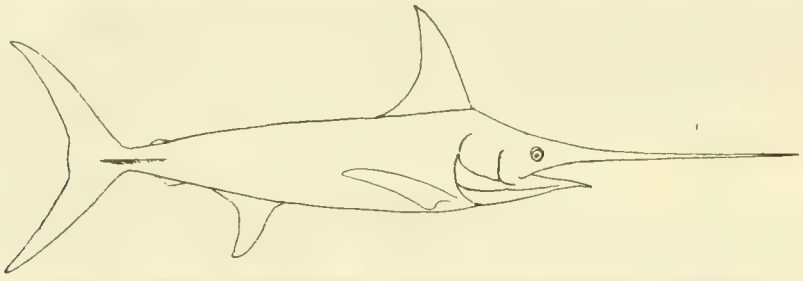

FIG. 102.—Swordfish (*Xiphias gladius*). After California Fish and Game Commission

but as broad as half the length of the fish from tip of lower jaw to base of caudal fin, with deeply lunate margin and pointed tips. There are no ventrals.[84]

Color.—While all swordfish are dark above and whitish with silvery sheen below, the upper surface varies from purplish to a dull leaden blue or even black. The eye has been described as blue. Young swordfish, like young tuna, are transversely barred, but none small enough to show this pattern has ever been found within the limits of the Gulf.

Size.—Swordfish grow to a great size. The largest definitely recorded from the Gulf of Maine was one killed off Portland, Me., in 1874, weighing 639 pounds salted, and hence must have "gone" at least 750 pounds alive. The heaviest landed in Massachusetts during 1922 weighed 637 pounds dressed; that is, upward of 700 pounds live weight.[85] About 16 feet seems to be the maximum length, but fish as long as this are certainly very rare. One or more 500-pounders are reported almost every year (the last big one we ourselves heard of was one of 536 pounds taken by the schooner *Two Sisters* in August, 1922), but the average for the larger run of Georges Bank and Gulf of Maine fish is only about 11 feet and 300 pounds

[84] In the sailfishes and spearfishes the body is scaleless, the jaws are toothed, ventral fins are present, and the first dorsal fin is much longer than that of the swordfish.

[85] Gloucester Times, Apr. 26, 1923.

live weight. Block Island fish run smaller. A 7-foot fish weighs about 120 pounds; 10 to 11 feet long about 250 pounds; and a fish of 13 to 13½ feet, about 600 pounds, as taken from the water.

Swordfish fry are quite different in appearance from the adults, having but one long dorsal and one long anal fin, a rounded tail, both jaws equally elongate and toothed, and the skin covered with rough spinous plates and scales; but fish of half a pound weight such as are caught in abundance in the Mediterranean resemble the adults.

General range.—Both sides of the Atlantic Ocean, north to northern Norway, the Newfoundland Banks, and Cape Breton; south to latitude about 35° south. Also in the Mediterranean and Red Seas, about the Cape of Good Hope, and in the Indian and Pacific Oceans.

Occurrence in the Gulf of Maine.—The swordfish seems to have attracted little attention in the Gulf in colonial days, and though it has long supported a lucrative fishery off New England we know little more of its life to-day than when Goode (1883) gathered his "Materials for the History of the Swordfish."

The outer part of the continental shelf from Block Island east to La Have Bank is the chief center of abundance, with Nantucket Shoals and Georges Bank perhaps the favorite grounds. A few swordfish are seen off Massachusetts Bay and along the Maine coast every summer. During some summers, of which 1884 was one, large numbers appear there, and on these occasions they are killed all around the Gulf from Cape Cod to Browns Bank, with Jeffreys Ledge and a zone about 10 to 12 miles off the coast from Boon Island to Cape Elizabeth perhaps their favorite resort. During most years, however, the great majority keep to the offshore banks, and only odd fish are seen in the inner parts of the Gulf of Maine, and they are rarely seen in the Bay of Fundy. Thus we find only 2,511 pounds (say 10 or 12 fish) brought in by the shore fishermen of Cumberland County, 3 or 4 (800 pounds) landed in York County in 1919. A few are caught off the west coast of Nova Scotia every summer (in 1920, a good swordfish year, 4,700 pounds, or about twenty-odd fish, were landed along the Yarmouth County shore), and over the basin of the Gulf. They are never plentiful in the inner parts of the Gulf and rarely enter the Bay of Fundy. On the offshore banks, on the contrary, 25 or more are often seen in a day. Sometimes that many are in sight at one time, especially over the southwest slope of Georges Bank, and several thousand are killed every summer. In the year 1919, for example, vessels from Maine ports, hunting mostly east of Nantucket, brought in about 425,000 pounds. Massachusetts vessels brought in 712,000 pounds, equivalent, say, to 4,000 fish. In 1920, a big swordfish year, 2,258,051 pounds (something like 7,000 fish) were landed in the ports of Boston, Gloucester, and Portland, not to mention such as were carried to New Bedford, Newport, and New York.

Swordfish, like all fish, fluctuate in abundance from year to year. Thus they were more abundant in the summer and fall of 1904 than was ever known before; plentiful, too, during the next two years; less so until 1913; and very numerous again in 1920. But on the whole the catch runs much more even, year by year, than for most oceanic fish, seldom rising above 2,000,000 or falling below 1,000,000 pounds for the landings in Boston and Gloucester.

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The swordfish, like mackerel, tuna, and bonito, is purely a summer fish on the North American coast, appearing simultaneously off New York and Block Island, on Nantucket Shoals, and on Georges Bank sometime between the 25th of May and the 20th of June, but they are seldom on the Scotian Banks until somewhat later or in the inner parts of the Gulf of Maine before July. They are most numerous in July and August, and vanish at the approach of cold weather. This seasonal ebb and flow is clearly reflected in the catch, month by month (fig. 103). So far as we can learn, not one has ever been reported east of Cape Cod after the first days of November, and most of them are gone from the Gulf by the last week in October; but an odd fish has been taken off New York and New Jersey in December and even in January, the most recent report of such occurrence being of 13 entangled in line trawls set for tilefish in 95 to 125 fathoms off Long Island between December 20, 1921, and January 1, 1922.[86]

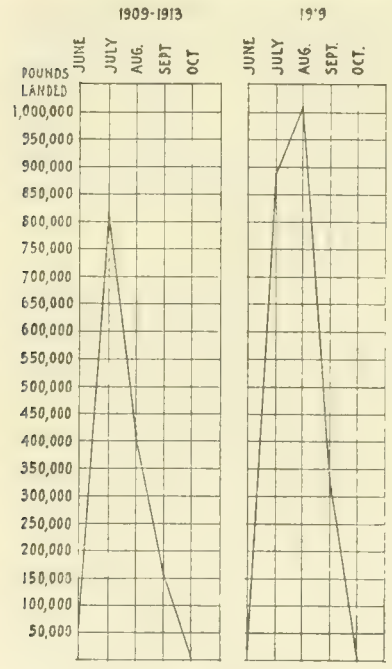

FIG. 103.—Monthly landings of swordfish for the year 1919 at Boston, Gloucester, and Portland, and average monthly landings in New England for the period 1909 to 1913

It is generally believed that swordfish come in from the open seas when they appear on the offshore banks in spring, some few to enter the Gulf of Maine, but the majority to remain about the banks at its mouth or to work slowly eastward along the outer part of the continental shelf, which is the only regular longshore migration they carry out. When they depart in autumn it is to return to the open Atlantic, but how far they go when they leave us, or how deep, is unknown. We are equally ignorant of where our local swordfish breed—certainly not in American coastwise waters, as no ripe fish have ever been seen there. In fact, most of the fishermen of whom we have inquired assure us they have never seen a trace of "spawn" in a swordfish, although they have dressed hundreds, and a "green" fish with ovaries weighing 15 pounds, brought into New Bedford on June 25, 1922, was considered so unusual that it caused much comment. Furthermore, it seems that very young fish never visit us, one of 7⅜ pounds, caught on Georges Bank by the schooner *Anna*, August 9, 1922, being the smallest so far recorded from off New England.[87] Goode, et al. (1884), it is true, describe a sword only one-half inch long found in the nostril of a mackerel shark caught at Gloucester, but there is no knowing how long the shark may have carried it, nor whence. One slightly more than 2 feet long with the sword and weighing about 24 pounds alive was also recorded by them, but fish smaller than 50 to 60 pounds are decidedly unusual. In the Mediterranean young fry as small as half a pound are often brought to market.

[86] Townsend, Science, new series. Vol. LVI, July-December, 1922, pp. 18–19. New York.
[87] U. S. Bureau of Fisheries Service Bulletin, No. 88, Sept. 1, 1922, p. 3.

Food.—The swordfish is a fish eater. During its stay in American waters it feeds on mackerel, menhaden, bluefish, silver hake, butterfish, herring, and indeed on any of the smaller schooling fishes, buckets of which have been taken from swordfish stomachs. Squid, too, are often found in them and may be their chief diet at times. One that we killed on Georges Bank on July 24, 1916, was full of silver hake, and another harpooned off Halifax contained a squid (*Ommostrephes*) and fragments of silver hake. They have often been described as rising through schools of mackerel, menhaden, etc., striking right and left with their swords, and then turning to gobble the dead or mangled fish. Judging from the commotion, we have seen them so employed on more than one occasion, though never close enough to actually follow the event. According to swordfishermen, it is not unusual for swordfish to contain black deep-sea fishes, and Kingsley [88] records two stomiatids (*Echiostoma barbatum* Lowe) taken from the stomach of one harpooned over the offshore slope of Georges Bank, so fresh that the phosphorescent organs were still in good condition, and since these black fish probably always keep below 150 fathoms this is sufficient evidence that swordfish sometimes forage at considerable depths. It seems that they sometimes endeavor to strip line trawls set for halibut and tilefish of the smaller fish already caught, for they are occasionally brought up entangled in the line, but never actually hooked.

Habits.—Swordfish are supposed to spawn in spring and early summer, but judging from the state of the ovaries and spermaries this can not apply to the American fish, which must spawn during the part of the year when absent from our coasts, and probably in the warmer parts of the Atlantic basin, for Lütken [89] found swordfish fry as small as 10 mm.—evidently hatched but a short time previous—between the latitudes of 20° and 39° N. The fact that they are thin when they return to us in spring, but fatten during the summer stay, is further evidence that they are spent before they appear off the coast.

Nothing is definitely known of the rate of growth of the swordfish. It has been supposed that the young fish of half a pound to 12 pounds taken in winter in the Mediterranean are the product of the past spring's spawning, but this would call for unusually rapid growth. The very large size attained may equally be the result of long life.

Although swordfish congregate temporarily in certain localities they do not school, but are always seen scattered about either singly or at most two fish swimming together. On this point the earlier published accounts, statements by fishermen, and our own rather limited experience are in accord. On calm days swordfish often lie quiet on the surface or loaf along with both the high dorsal and the tip of the caudal fin above water, and it is while so employed that they are harpooned. When at the surface swordfish do a good deal of jumping, perhaps in a vain attempt to shake off the remoras that so often cling to them. On July 28, 1914, off Shelburne, one leaped clear of the water four or five times in rapid succession close to the *Grampus*.

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[88] Science, new series, Vol. LVI, 1922, pp. 225–226. New York.

[89] Spolia Atlantica, 1880–1892. Kjøbenhavn.

Tales innumerable are current of swordfish attacking vessels, but most such happenings are really the work of some one of the round-sworded spearfishes, which seem either to be subject to fits of "temporary insanity," as Goode, et al. (1884, p. 345), called it, or, more likely, may strike a ship and pierce its planking while pursuing bonito or other fish in its shadow. Though many pleasure and fishing craft, large and small, cruise off our coasts every summer, we have never known of one being struck by a swordfish unprovoked, but fish that have been harpooned often turn on their pursuers and for one to so pierce the thin bottom of a dory is a common event. We have, indeed, known several fishermen to be wounded in the leg in this way, but always *after the fish had been struck with the harpoon.* Under these circumstances swordfish have been known to drive their swords right through the planking of a fishing vessel.

Stories of swordfish attacking whales are time-honored traditions of the sea, with no more stable foundation than the myth that they ally themselves with the harmless thresher shark for the purpose. As a matter of fact swordfish are easily frightened, but for some occult reason they will allow themselves to be almost run down by a large vessel without paying the least attention to its approach until aroused by its shadow or by the swirl of water under its forefoot, though I have never heard of a swordfish actually being struck by a vessel. They always sound or dart aside in time. When harpooned swordfish fight gamely on the surface or below. Storer long ago wrote that they sometimes sound with such speed and force as to drive the sword into the bottom, which fishermen say is by no means uncommon, and we ourselves saw an instance of this off Halifax in August, 1914, when a fish over 10 feet long, which we had harpooned from the *Grampus,* plunged with such force that it buried itself in the mud beyond the eyes in 56 fathoms of water. When finally hauled alongside it brought up enough mud plastered to its head to yield a good sample of the bottom.

How far temperature governs the distribution of swordfish is yet to be learned. It is safe to say that it is a warm and not a cold-water fish, most plentiful in waters warmer than 50°; but occasional captures on halibut line trawls set near bottom as deep as 200 fathoms, together with the fact that swordfish are by no means rare on the Newfoundland Banks, whence several fish were brought back by the American cod fleet in 1920, proves that temperatures lower than 50° are not a bar to it.

Full-grown swordfish are so active, powerful, and well armed that they can have few enemies. Sperm and killer whales and the larger sharks alone menace them, and while we can find no evidence that swordfish ever fell prey to the first two, Captain Atwood found a good-sized swordfish in the stomach of a tiger shark as recorded above (p. 28), and one swordfisherman of our acquaintance described seeing two large sharks bite or tear off the tail of a swordfish of 350 pounds, which he afterwards harpooned. Young swordfish would, of course, be preyed upon by any of the larger predaceous fishes.

Swordfish are infested with many parasites besides the remoras, several of which are often found clinging to one fish. No less than 12 species of worms and 6 of copepods have been identified from fish taken off Woods Hole alone.

Swordfish are harpooned. We have never heard of one caught in net or seine, nor is it likely that any net of the sorts now in use would hold a large one. On rare occasions swordfish have been taken on hand lines baited for cod with mackerel or other fish. Goode (1883), for example, relates an instance where seven were so caught in one day in the South Channel in 15 to 25 fathoms, and fishermen have told us of other such happenings.

Commercial importance.—Appreciation of the swordfish in the market is of recent growth. Down to the middle of the past century it was unsalable in Boston and brought a very low price in New York, but of late years the demand would take care of a much greater supply than is available. In 1919 the price to the fishermen averaged between 23 and 24 cents per pound.[90]

THE SAILFISHES. FAMILY ISTIOPHORIDÆ

Sailfishes, like the swordfish, have a "sword" formed by the prolongation of the snout and upper jaw. They are scaly, however; their teeth persist throughout life; they have long ventral fins; and their dorsal fins occupy the greater part of the back behind the nape; characters that separate them at a glance from the swordfish family. Five species are known—all oceanic and subtropical—only one of which has ever been taken within the limits of the Gulf of Maine, though a second (the sailfish) might stray thither (p. 228).

FIG. 104.—Spearfish (*Tetrapturus imperator*)

KEY TO GULF OF MAINE SAILFISHES

1. First dorsal fin much higher than the body is deep; ventrals of 3 rays.....Sailfish, p. 228
   The first dorsal fin is not higher than the body is deep; ventrals reduced to one spine each.....Spearfish, p. 227

84. **Spearfish** (*Tetrapturus imperator* Bloch and Schneider)

BILLFISH

Jordan and Evermann, 1896–1900 (*Tetrapturus albidus*), p. 892.

Description.—The spearfish parallels the common swordfish in the prolongation of the bones of the upper jaw and snout to form a sword, but differs so widely from it in the relative size and outlines of its fins that there is no danger of confusing the two. Perhaps the most obvious difference is that its first dorsal fin [91] occupies

[90] Landings in Maine and Massachusetts: 1,136,542 pounds valued at $270,164.

[91] In very young spearfishes there is but one continuous dorsal fin, which later separates into two.

fully two-thirds of the length of the trunk from the nape backward, and is, furthermore, of very characteristic falcate outline. But more important systematically, if less apparent, is the fact that the adult spearfish has ventral fins which the swordfish lacks, though they are reduced, it is true, to one long spine each (actually 5 fused together). Furthermore, its second dorsal and anal fins are relatively larger and its pectoral smaller than those of its relative, while there are two small longitudinal keels on either side of its caudal peduncle instead of one broad one; its sword is only about half as long, proportionately, as that of the swordfish, much narrower, and round instead of sharp edged; its body is more slender; and its head is relatively shorter. Careful examination would show that the spearfish is not naked but has small scales imbedded in the skin and that there are small teeth in its jaws and on the roof of its mouth.

The spearfish is deepest abreast the pectorals, about six and one-fourth times as long (not counting the caudal fin) as deep, tapers evenly to the caudal peduncle, and its upper jaw in front of the eye (including the sword) is twice as long as the length of the head behind the eye. In a specimen from Massachusetts, illustrated by Goode (1883, Pl. IV), and reproduced herein as Figure 104, the first dorsal fin (35 to 39 stiff rays) is separated from the short second (6 soft rays) by a space equal to twice the length of the latter, and the second anal fin is similar to the second dorsal in outline but is situated slightly in front of it. The first anal fin (2 spines and 13 rays) is triangular, with rounded tip and slightly falcate rear margin, situated below the rear part of the first dorsal. The ventrals are below the pectorals, and the caudal is even shorter and broader than that of the swordfish and similarly lunate in outline.

Color.—Described as deep blue above, white below, with intense blue fins, the dorsal spotted with darker blue, and a blue iris.

Size.—Said to reach a length of 26 feet, but few longer than 7 feet are seen.

General range.—Warm parts of the Atlantic, north to Cape Cod.[92]

Occurrence in the Gulf of Maine.—This southern fish is included here because one was brought in by the fishing schooner *Phoenix* from the South Channel some time between 1877 and 1880, this being the most boreal record for it. It is taken from time to time at Woods Hole.[93]

THE POMPANOS. FAMILY CARANGIDÆ

The pompanos are allied to the mackerels, like which they have two dorsal fins, the first spiny and the second soft; very deeply forked tails; very slender caudal peduncles; and ventrals thoracic in position—that is, below the pectorals. They are readily separable from the mackerels, however, by the fact that the first

[92] The south European and American spearfishes are now generally considered identical.

[93] The sailfish (*Istiophorus nigricans*), so common in the warmer parts of the Atlantic, has been taken at Woods Hole on several occasions, but has not yet been recorded from the Gulf of Maine. It is readily recognizable by the fact that the first dorsa fin is much higher than that of the spearfish, while the ventral fins of the sailfish are two or three rayed instead of being reduced to a single spine, as in the spearfish. The two dorsal fins of the sailfish have usually been described as connected even in the adult. This, in fact, is given as the chief distinction between Tetrapturus and Istiophorus by Goode (Report, U. S. Commissioner of Fish and Fisheries, 1880, p. 296), by Jordan and Evermann, and by Boulenger (Cambridge Natural History, Vol. VII, 1904, p. 680), but there is actually a considerable gap between the two fins in large specimens, as Bean (The food and game fishes of New York, 1903) remarks in his account of *I. nigricans*, and as appears on Goode's own illustrations of a sailfish taken at Newport, and of a skeleton.

(spinous) dorsal is much shorter than the second (soft rayed), if present (it may be reduced to a series of very short spines or may be lost altogether in old age), and that they either lack the dorsal and anal finlets so characteristic of the mackerel tribe, or at most have but one of each. They differ further from the mackerels in the number of vertebræ (only 22 to 23 as against upward of 30), as well as in the facts that the premaxillary bones are protractile (fixed in the mackerels) and that the anal fin is preceded by two free spines that may either take the form of a permanent finlet or may be lost in old age. Warm seas support a host of species but none of them is more than an accidental stray to the Gulf of Maine.

KEY TO GULF OF MAINE POMPANOS

1. Body very much compressed, nearly or quite half as deep as long, or even deeper 2
   Body moderately stout, not more than one-third as deep as long 4
2. Back and belly rounded; pectoral fin reaches not over two-thirds the way back toward the base of the caudal ..... True pompanos (genus Trachinotus)
   Back and belly sharp edged; pectoral fin reaches at least halfway back toward the base of the caudal 3
3. Soft dorsal[94] and anal fins are low and taper evenly from front to rear ..... Moonfish, p. 235
   The soft dorsal and the anal fins are both very high in front and taper abruptly toward the rear ..... Lookdown, p. 236
4. There is only one well-developed dorsal fin (the soft rayed), the first (spiny) dorsal being reduced to a few short inconspicuous spines ..... Pilotfish, p. 229
   There are two well-developed dorsal fins, though the second (soft) is much larger than the first (spiny) 5
5. There is a detached finlet behind the second dorsal fin, and one behind the anal fin ..... Mackerel scad, p. 232
   There are no finlets behind the dorsal and anal fins 6
6. There is a small finlet of two stout spines *in front* of the anal fin, and the latter is nearly as long as the second dorsal 7
   There is no finlet in front of anal fin (in young fry it is represented by two spines so short they are apt to be overlooked), and the anal is at least one-third shorter than the second dorsal ..... Rudderfish, p. 230
7. Breast entirely scaly ..... Hardtail, p. 234
   Breast naked except just in front of the ventral fins ..... Crevalle, p. 233

85. **Pilotfish** (*Naucrates ductor* Linnæus)

RUDDERFISH; SHARK PILOT

Jordan and Evermann, 1896–1900, p. 900.

Description.—The pilotfish is stouter than the common mackerel (about one-fourth as deep as long)—to take a familiar comparison—with blunter, rounded nose, smaller mouth, and eye situated farther forward. Its long second dorsal separates it from all the mackerel tribe, but its caudal peduncle is slender and keeled on either side like that of a bonito. The first dorsal is reduced to four short inconspicuous spines, which are connected by a membrane in young fish but this is lost with growth. The second dorsal (26 or 27 soft rays) is slightly concave in

[94] In the adult the first dorsal is reduced to a few short isolated spines, but in young fry some of these spines are elongated.

outline and originates midway from snout to base of caudal. The anal is similar to it in form, but only about half as long (16 or 17 rays), preceded by two very short spines. In this it resembles the rudderfish, but the first dorsal of the latter is well developed and has 7 instead of 4 spines. The ventrals are situated far forward under the pectorals, and are about as large as the latter. The caudal is large and deeply forked. In the adult the edge of the gill cover is rounded but it bears a spine in young fry.

Color.—Bluish, transversely barred with 5 to 7 dark bands, two or three of which run up on the dorsal and down on the anal fins. The outer margins of caudal, ventral, and pectoral fins are nearly black. The caudal is white-tipped.

Size.—Maximum length about 2 feet.

General range.—A tropical fish of the high seas, rarely straying as far north as Maine.

Occurrence in the Gulf of Maine.—There are only two definite records for the Gulf of Maine—one near Seguin Island in Maine (1908) and one of a specimen taken in a mackerel net at Provincetown Harbor in October, 1858, the fish having

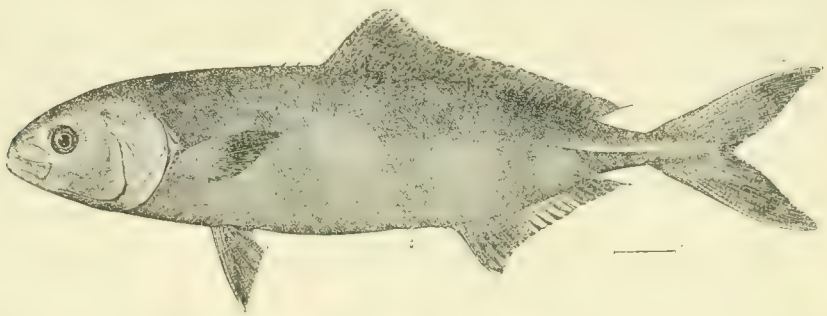

FIG. 105.—Pilotfish (*Naucrates ductor*)

probably followed a whale ship that arrived a few days previous. We need merely remark that this is the fish that so commonly attends sharks in tropic seas, either picking up a living from the scraps left by the latter, or feeding on the parasites with which their protectors are infested, and which so often follows sailing vessels.

86. **Rudderfish** (*Seriola zonata* Mitchill)

PILOTFISH; SHARK PILOT

Jordan and Evermann, 1896–1900, p. 902.

Description.—The rudderfish much resembles the pilot, but it is relatively deeper bodied (total length three and one-eighth times the depth), so much compressed that it is almost as thin as a butterfish (p. 245), and with more pointed nose. The chief distinction, however, is that its first (spinous) dorsal is well developed, and with 7 instead of only 4 spines. Furthermore, there are 37 to 38 instead of only 26 to 27 rays in the second dorsal fin and the ventrals are relatively

much longer. In young fry of 2 to 3 inches (none larger than this have ever been seen north of Cape Cod), the second dorsal originates somewhat in *front* of the tip of the pectoral, but by the time the fish has grown to 8 or 9 inches in length we find it originating slightly *behind* the tip of the pectoral, and in larger fish it stands still farther back.[95]

In the rudderfish, as in the pilotfish, the anal (20 to 21 rays) is little more than half as long as the second dorsal. In young fish it is preceded by one or two short spines which adults lack. The ventrals are slightly longer than the pectorals, and more pointed in large than in small specimens; the caudal is deeply forked, its slender peduncle keeled; and the mouth is of moderate size, gaping back to the forward margin of the eye and armed with broad bands of hairlike teeth. The body is clad with small scales.

Color.—Described as bluish or silvery brown above, paler on the sides, and white below. In young fish the sides are crossbarred with five or six broad dark blue or brown bands, the last four of which run up on the dorsal and the last two

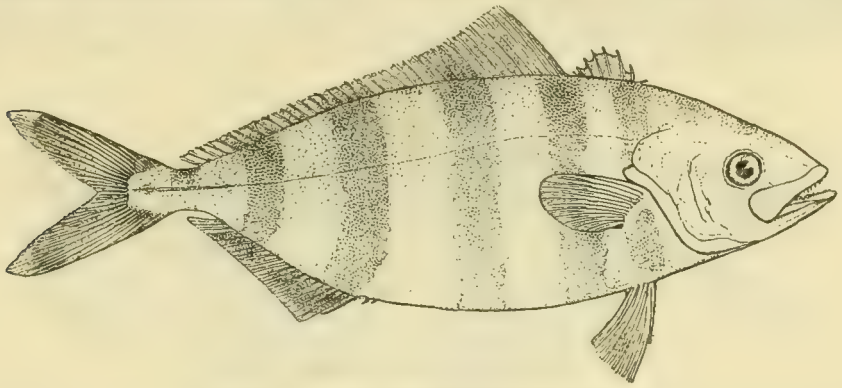

FIG. 106.—Rudderfish (*Seriola zonata*). After Storer

or three down on the anal fin. There is a dark band running obliquely from the first dorsal to the eye. All of these bands fade with growth, however, to disappear in large fish. The first dorsal is black, the anal white at the base, the ventrals black above, pale below, and the caudal dusky green with white tips.[96]

Size.—Maximum length about 3 feet.

General range.—Atlantic coast of America—Massachusetts Bay to Gulf of Mexico.

Occurrence in the Gulf of Maine.—The rudderfish has not been definitely recorded from the Gulf for many years, its claim to mention here resting on two specimens taken at Wellfleet in 1844 and 1849 and mentioned by Storer, one at Beverly in May, 1866, and one at Salem sometime prior to 1879. Small fry 1½ to 7 inches long are regular summer visitors at Woods Hole, however.

[95] We have examined specimens ranging from 3 to 9 inches in length taken at Woods Hole, New Bedford, and other localities. Storer's illustration (1853–1867), reproduced here, was of a 2-inch fish

[96] We have not seen this fish alive.

87. **Mackerel scad** (*Decapterus macarellus* Cuvier and Valenciennes)

Jordan and Evermann, 1896–1900, p. 909.

Description.—The scads are easily recognized among pompanos by the presence of a small detached finlet between the second dorsal and the base of the caudal fin [97] with another similar to it behind the anal. Furthermore, they are more slender than most other pompanos, being only about one-fifth as deep as long, and fusiform like a mackerel, but the great length of the second dorsal fin and the fact that there is only one dorsal and one anal finlet would separate a mackerel scad from a mackerel at a glance. The nose of the scad is blunter, its snout shorter, its mouth smaller, and its premaxillary bones are protractile. The triangular first dorsal fin (8 spines) originates over the middle of the pectoral. The second dorsal (about 34 rays) is separated from it by only a very short space and extends back nearly to the base of the caudal. The anal is similar to the second dorsal in form but shorter (34 to 27 rays), originating about under the seventh or eighth ray of the latter, and it is preceded by 2 short stout spines. The ventrals are shorter than the pectorals and below them. The tail of the scad is less deeply forked than

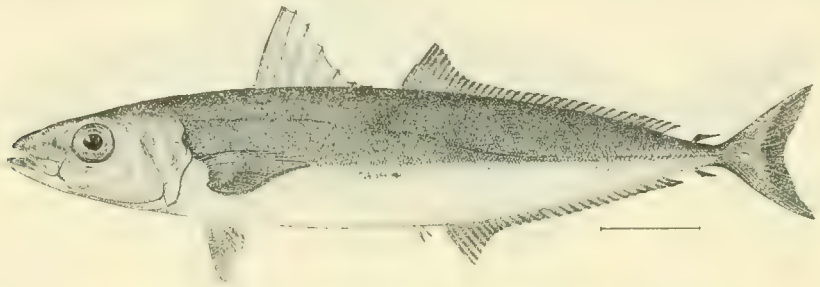

FIG. 107.—Mackerel scad (*Decapterus macarellus*)

in most pompanos. In place of fleshy keels on the caudal peduncle, the posterior half of the lateral line is armed with a series of about 31 keeled shields, largest on the peduncle, and all of them much larger than the ordinary scales—a very noticeable character.

Color.—Described as slate blue or leaden above, silvery below, with a small black spot on the margin of the gill cover and with the axil of the pectoral black. We have not seen it alive.

Size.—Maximum length about 1 foot.

General range.—Warm parts of the Atlantic, rarely straying northward to the Gulf of Maine and to Nova Scotia.

Occurrence in the Gulf of Maine.—A single specimen caught with smelt in Casco Bay, Me., in 1920 is the only Gulf of Maine record, though it has been taken at Canso, Nova Scotia, but being common in the autumn about Woods Hole, where as many as 10 barrels have been taken from one trap haul, it would not be surprising to find it north of Cape Cod.

[97] A second scad, the "round robin" (*Decapterus punctatus*), similarly characterized, is known as far north as the Woods Hole region. It has 40 or more scutes or shield scales on the lateral line, instead of only about 30 or 31; its jaws are toothed, and it is spotted along the lateral line, characters that separate it from the mackerel scad.

88. Crevalle (*Caranx hippos* Linnæus)

Jordan and Evermann, 1896–1900, p. 920.

Description.—The presence of a well-developed first dorsal (8 spines) combined with an anal (about 17 rays, preceded by 2 short detached spines) nearly as long as the second dorsal (about 20 rays), but *no* detached finlets, separates the crevalle from all pompanos yet known from the Gulf except for the hardtail (p. 234), and whereas the breast of the latter is scaly like the rest of the body, this region is largely naked in the crevalle. Furthermore, the lower jaw of the latter is armed with a pair of canine teeth, wanting in the hardtail, and the dorsal profile of its head is different (compare fig. 108 with fig. 109). The long scimitar-shaped pectoral fins also afford a convenient field mark to separate crevalle, hardtail, and yellowtail (*Chloroscombrus chrysurus*) from pilotfish, rudderfish, and scads, in which the pectorals are short and blunter. We need only call attention further to the deeply forked tail, the row of keeled shields on either side of the caudal peduncle, the flattened oblong form (only about two and one-half times as long as deep, but with caudal peduncle as slender as that of a mackerel), and to the blunt head.

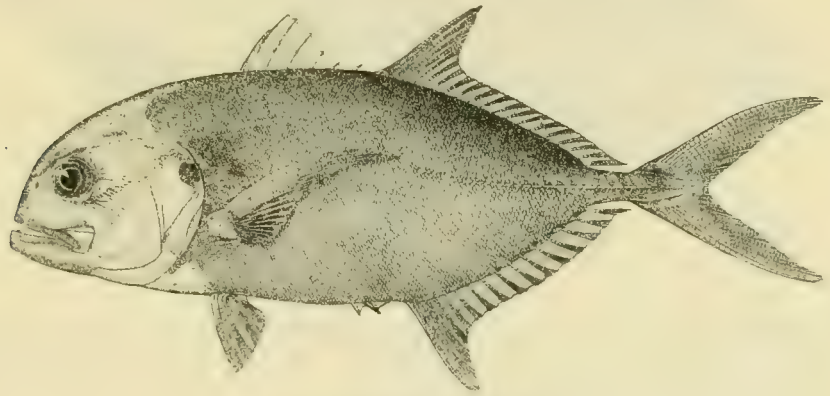

FIG. 108.—Crevalle (*Caranx hippos*)

Color.—Described as olive above with golden sides and belly. There is a large black blotch on the gill cover, a faint dark spot on the lower rays of the pectorals, and a black blotch in their axils. The edge of the second dorsal is black.

Size.—Maximum weight about 20 pounds.

General range.—Warm seas; abundant on both coasts of America; also occurring in the East Indies.

Commercial importance.—A famous game fish but not very much valued for the table.

Occurrence in the Gulf of Maine.—We know but one record of this southern fish east or north of the southern angle of Cape Cod—a specimen picked up on Lynn Beach on the shore of Massachusetts Bay during the summer of 1847. At Woods Hole, however, it is a regular, if uncommon, summer visitor.

89. **Hardtail** (*Caranx crysos* Mitchill)

RUNNER; YELLOW MACKEREL

Jordan and Evermann, 1896–1900, p. 921.

Description.—The hardtail closely resembles the crevalle in the relative sizes and arrangement of its fins, in its deeply-forked tail, its slender caudal peduncle, and in the row of bony shields along the posterior half of its lateral line; but it is a more slender fish (about three and one-fourth instead of only two and one-half times as long as deep), the dorsal profile of its head is not so convex, there are no canine teeth, and the shields are more numerous (about 45 in hardtail and only about 30 in crevalle). Furthermore, its breast is wholly scaly instead of mostly naked, and the pectoral fin spot, characteristic of the crevalle, is wanting in the hardtail.

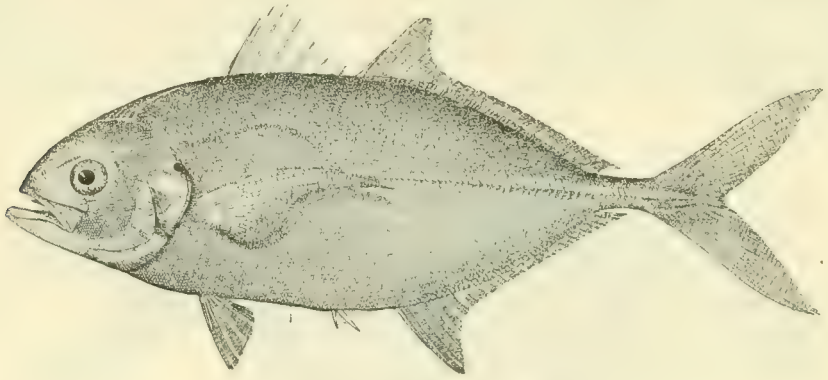

FIG. 109.—Hardtail (*Caranx crysos*)

Color.—Olive green above; golden to silvery below; a black spot on the gill cover near its margin but *none* on the pectoral fin. Young fry are more or less barred on the sides, but these bars disappear with growth.

Size.—Maximum weight about 3 pounds. Northern examples are seldom more than a foot long.

General range.—Atlantic coast of America, Brazil to Cape Cod, and represented by a closely allied species in the Pacific.

Occurrence in the Gulf of Maine.—The fact that this fish has been reported from Provincetown, in Boston Harbor, off Gloucester,[98] in Ipswich Bay,[99] and from Nova Scotian waters, shows that it is more apt to round Cape Cod than is the crevalle, but so rare a stray is it in the Gulf that none of the local fishermen with whom we have talked know it there. Young fish are not rare about Woods Hole and thence westward from July until November.

[98] One netted Sept. 18, 1878.

[99] Specimen now in the collection of the Boston Society of Natural History.

90. **Moonfish** (*Vomer setapinnis* Mitchill)

SHINER; HORSEFISH; BLUNTNOSE; DOLLARFISH

Jordan and Evermann, 1896–1900, p. 934.

Description.—The very deep, compressed, sharp-edged body of the moonfish (adults are only about twice as long as deep, and young fry even deeper, relatively), tapering to the usual slender caudal peduncle, and the concave profile of its head, separate it at a glance from pilotfish, scad, crevalle, hardtail, or yellowtail (*Chloroscombrus chrysurus*), and the very low dorsal and anal fins obviate any danger of confusing it with the lookdown (p. 236), which is of something the same shape (compare fig. 110 with fig. 111). The first dorsal of the adult moonfish is reduced to four very short, inconspicuous, detached spines, but in young fry the first two of these are elongate and filamentous. The second dorsal fin (21 to 27 rays) and the anal fin (19 to 20 rays) are about equal in length, both of them very low and tapering very slightly from front to rear. In very small fish the second to fourth

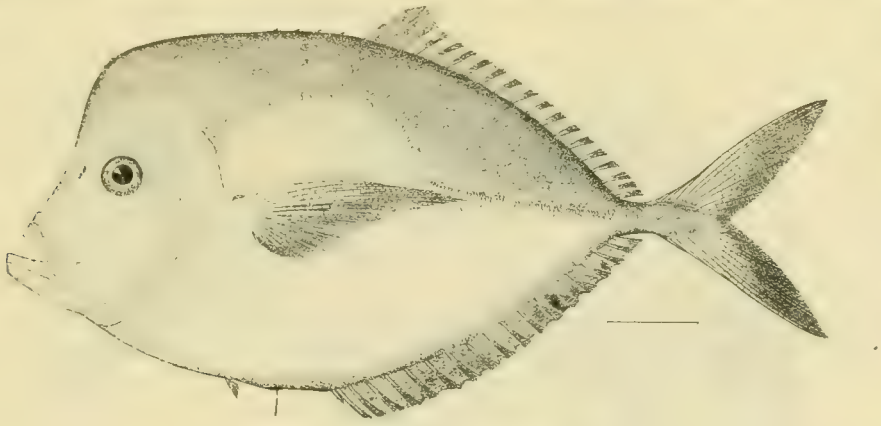

FIG. 110.—Moonfish (*Vomer setapinnis*)

rays of the second dorsal are more or less elongate, and the anal is preceded by 3 or 4 short detached spines which are not to be seen in the adult. The ventrals are so small that they are apt to be overlooked except in young fry, where the ventral rays, like the dorsal spines, are long and filamentous. The pectorals are falcate, the scales on the lateral line are not large enough to be conspicuous, and the teeth are very small. There are no detached finlets, dorsal or anal.

Color.—Described as leaden to greenish above with silvery or golden sides and belly, the second dorsal light yellow at its base and punctated with black, and the pectorals dusky greenish.

Size.—About 1 foot long.

General range.—Warm seas off the east coast of America from Brazil to Cape Cod, rarely to Nova Scotia; common from Chesapeake Bay southward.

Occurrence in the Gulf of Maine.—The moonfish reaches the Gulf only as a waif from warmer waters, but it has been taken more often there than any other of its

tribe. There are records for Gloucester (several specimens), Magnolia, Danvers, Salem, and South Boston (a specimen 2 inches long), in Massachusetts; for Saco Beach (fry of about 1 to 3 inches) and Casco Bay, in Maine. Fry have even been reported once or twice as far east as Halifax, Nova Scotia, but most of these records date back many years and none of the fishermen of whom we have inquired know it at all north of Cape Cod. It appears more often, if irregularly, at Woods Hole, where young fish are sometimes common in August and September.

91. **Lookdown** (*Selene vomer* Linnæus)

HORSEHEAD; MOONFISH

Jordan and Evermann, 1896–1900, p. 936.

Description.—The very high second dorsal (about 22 rays) and anal fins (about 20 rays) of the lookdown, and their peculiar falcate outline, with the second ray

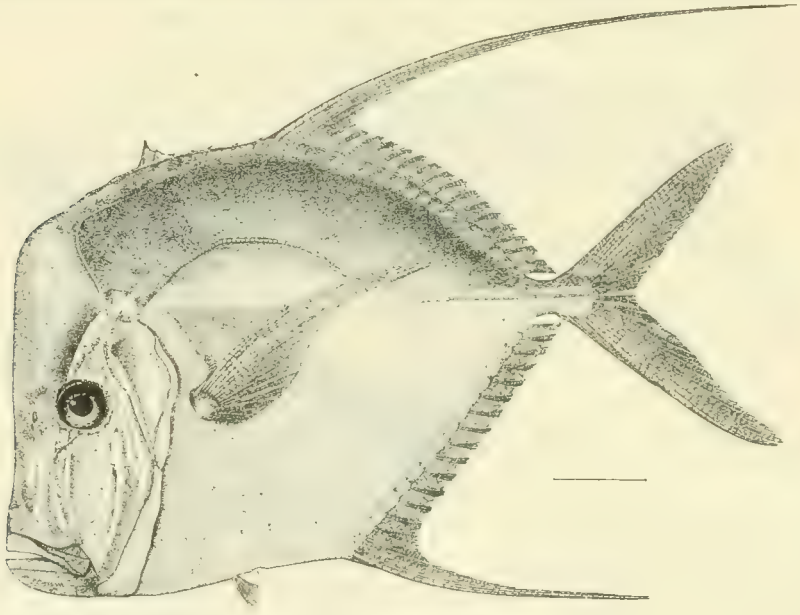

FIG. 111.—Lookdown (*Selene vomer*)

much the longest and the next 4 or 5 rays successively shorter and shorter, make distinction between it and the moonfish easy. Hardly less characteristic is its peculiar form, for it shares with the moonfish a deep, rhomboid, but very thin flat body (the fish is only about one and one-half times as long as deep), abruptly truncate in front, with slightly concave profile, but tapering rearward to a slender caudal peduncle. The mouth is set so low and the eye so high that the expression of its face is very characteristic. When adult the first dorsal is reduced to 6 or 7 short inconspicuous spines, only the first 3 of which are connected by a membrane, and the ventrals are very small; but in fry up to 4 or 5 inches long some of the spines of the first dorsal are greatly elongate, the ventrals are much longer, and the

anal is preceded by a short detached spine that disappears with growth. The caudal fin is deeply forked like that of other pompanos and the pectorals are sharp pointed and falciform, reaching back behind the middle of the second dorsal.

Color.—Small specimens—and northern strays are usually small—are silvery above as well as below, with the ground tint of the back leaden, the sides barred with several crossbands, variously described as dark or golden. These bands fade out with growth, however.

Size.—Grows to a weight of 2 pounds.

General range.—Warm waters on the east and west coasts of America, north rarely to Cape Cod, and casual in the Gulf of Maine. Common from Chesapeake Bay southward.

Occurrence in the Gulf of Maine.—We find only three records for the lookdown in the Gulf—two for Casco Bay and one for Dorchester, in Massachusetts Bay. Hence, since no one would be apt to overlook so bizarre a fish, it must be a very rare straggler from the south.

THE BLUEFISHES. FAMILY POMATOMIDÆ

The bluefish (the only member of the family) resembles the pompano family in the general structure and arrangement of its fins, there being two dorsals, spiny and soft, with the ventrals thoracic in situation; but it lacks the free spines in front of the anal fin which are characteristic of most pompanos, its caudal peduncle is deeper, its tail less deeply forked, and its teeth are much larger. In its general body form and in the arrangement of its fins it bears a superficial resemblance to certain of the weakfish family (p. 269), but is readily separable from any of the latter by the fact that its anal fin is nearly as long as the soft (second) dorsal, and from the sea-bass family because its first (spiny) dorsal is much lower than the second. Most American ichthyologists look upon the bluefish family as closely allied to the pompanos, but according to another view it should be grouped with the sea-bass tribe because of skeletal characters.

92. **Bluefish** (*Pomatomus saltatrix* Linnæus)[1]

SNAPPER (YOUNG)

Jordan and Evermann, 1896–1900, p. 946.

Description.—According to Jordan and Evermann and to most of their successors, the bluefish is separable from its closest allies, the pompanos (Carangidæ), by a tail "not deeply forked" and by the larger scales, statements that may easily be misleading, for while the bluefish certainly has a *less* deeply forked tail than the pompanos, anyone, we think, would describe it as *deeply* forked as compared with any square-tailed fish, and while its scales are larger than those of most pompanos there is not much difference in this respect between a bluefish and a large crevalle (p. 233). There is, however, one positive point of difference. The jaws of the

[1] This fish has been known by various vernacular names along the middle and southern coasts of the United States. In the Gulf of Maine, however, it is simply the "bluefish."

bluefish, upper as well as lower, are armed all around with a single series of stout, conical, canine teeth (one-eighth to one-fourth of an inch long in a fish of about 10 pounds), whereas the crevalle alone of northern pompanos has canines and then only two. Furthermore, the caudal peduncle of the bluefish is stouter than that of any pompano. It is sharply differentiated from all mackerels by the absence of dorsal or ventral finlets.

The bluefish is moderately stout bodied, about one-fourth as deep as long; its belly flat sided but blunt edged below; its caudal peduncle moderate (slimmer, however, than in many other fish, e. g., striped bass); its head deep; its nose moderately pointed; and its mouth large and oblique with projecting lower jaw and very prominent canines. The first dorsal (7 to 8 stout spines), originating over the middle of the pectoral, is low, rounded, depressible in a groove, and separated by only a very short interval from the second, which is more than twice as long (about 25 soft rays) and about twice as high, tapering backward with slightly concave margin. The anal (about 25 rays) is similar in form to the second dorsal, but originates somewhat farther back and is preceded by a very short detached

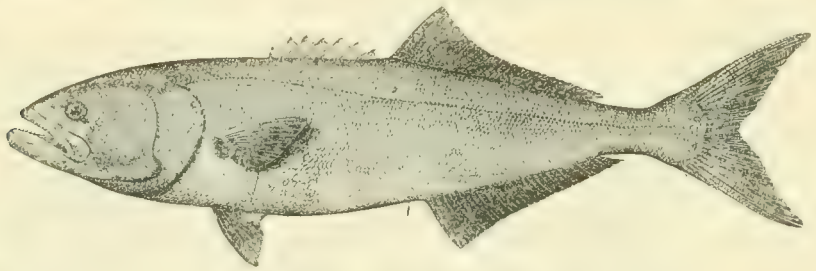

FIG. 112.—Bluefish (*Pomatomus saltatrix*)

spine often hidden in the skin. The caudal is broad and forked—"moderately" or "deeply," according to what other fish it is compared with. The ventrals and pectorals are both of moderate size. The body, most of the head, and also the second dorsal and anal fins are clothed with medium-sized scales. There are *no* shields or keeled scales along the lateral line nor is the caudal peduncle keeled.

Color.—Deep bluish above, more or less tinged with green; silvery below. The second dorsal, caudal, and pectoral fins are of the general body tint, the latter with a black blotch at its base.

Size.—Maximum length about 3 feet. The heaviest of which we find definite record within recent years was 3 feet 9 inches long and weighed 27 pounds.[2] It was caught off Nantucket in 1903. It is said that fish of 30 or even 50 pounds were not unheard of during the last half of the eighteenth century, but these monsters may not have been actually weighed. The general run of the large fish that are caught is only 10 to 15 pounds. A 1-pound fish is about 14 inches; a 2-pounder about 17 inches; a 3-pounder about 20 to 21 inches; a 4-pounder, 2 feet; and an 8-pounder about 28 to 29 inches long. Fish running from 10 to 12 pounds are about 30 inches.[3]

[2] Smith. Forest and Stream, Vol. 61, Oct. 10, 1903, p. 283.
[3] Goode, et al., 1884.

General range.[4]—Widely but irregularly distributed in the warmer parts of the Atlantic and Indian Oceans. North to the Gulf of Maine on the Atlantic coast of the United States.

Occurrence in the Gulf of Maine.—So far as we can learn bluefish have never been taken in the Bay of Fundy or off the Nova Scotian side of the Gulf. In fact they have very seldom been seen east of Penobscot Bay (reported at Mount Desert in 1889), and so far as the Gulf is concerned it seems that they are confined to the neighborhood of the coast, for they are unknown in the central basin or on Georges Bank. Small bluefish ("snappers") run up into protected harbors, such as Provincetown and Duxbury, and river mouths into brackish water. The larger sizes (3 pounds or more), however, keep to the outside waters.

The most interesting aspect of the occurrence of bluefish in the Gulf of Maine is, that while it has been known to swarm there for several summers in succession, it may then be so rare over periods of many years that the capture of even a single fish causes remark. At the time of the first settlement bluefish must have been common, at least as far north as what is now southern Maine, for Josselyn, writing in 1672, spoke of them there and was evidently familiar with them on the table, describing them as better meat than the salmon. There is no record of them north of Cape Cod during the seventeenth century, however.

In colonial times bluefish were plentiful off southern New England and about Nantucket, but they seem to have disappeared thence about 1764, to reappear about 1810. From that time on they increased in abundance west and south of Cape Cod, but none was reported north of the cape until 1837, and since a fish as ubiquitous as the bluefish would certainly have attracted attention and its presence would have found its way into print had it been at all abundant in the Massachusetts Bay region, it is safe to say that very few, if any, visited the Gulf of Maine during the eighteenth century or the first quarter of the nineteenth. According to Storer, the first bluefish seen north of Cape Cod thereafter was one caught on October 25, 1837, and in 1838 Captain Atwood (1863, p. 189) saw them for the first time at Provincetown; but after 1844, according to Storer, bluefish were taken yearly from the wharves at Boston, and they came in greater numbers year after year, until by 1850 they were so plentiful about Cape Ann that fishermen complained of them driving away most of the other schooling fish, while in 1863, which seems to have marked the culmination of the flood tide of bluefish, they were extremely abundant in the Massachusetts Bay region and especially at Provincetown.[5] They remained plentiful in the southern part of the Gulf of Maine for several summers after 1863, but by 1872 they were reported as much less abundant off Gloucester, and they were no longer sufficiently plentiful north of Cape Cod to menace the local mackerel fishery after 1878 or 1879.

Bluefish have never appeared in any numbers north of Boston since 1889,[6] in which year they were reported common as far north as Mount Desert, but considerable numbers were taken along the inner as well as the outer shores of Cape Cod

[4] Although bluefish are said to range as far north as Nova Scotia (Halkett, 1913, p. 42), we have found no recent report of them beyond the westernside of the Gulf of Maine.

[5] Baird (1873) and Goode et al. (1884) have collected much data on the early history of the bluefish.

[6] None was reported north of Plymouth in 1887 or 1888.

until about 1897, a season when the traps on its east and west sides accounted for about 9,000 pounds. Since that time, however, the catch of bluefish for the whole Gulf of Maine has never again been so large. From 1906 until 1911 the returns for the Gulf of Maine shores of the cape ran from less than 100 to about 4,000 pounds yearly, the north shore of Massachusetts Bay yielding from none at all up to 600 pounds. Since 1917, when the State of Massachusetts resumed publication of the pound-net statistics after a lapse of 5 years, the largest annual catches north of the elbow of Cape Cod have been 668 pounds (about 60 or 70 fish) caught off Essex County, Mass., during the summer of 1919, and 521 pounds taken in the traps near Gloucester in 1921, in which summer (as we have been informed) some small bluefish 4 to 5 inches long were also caught off Plymouth, and at least one small bluefish (about 1½ pounds) was taken at Beverly, Mass., in July, 1922, with a lot of shad, which it may have been following.

For the past 30 years Cape Ann has been the extreme northern boundary for this fish, except that some young fry (about 2¼ inches long) were taken in Casco Bay in August, 1899, and a few small-sized fish (but no adults) there the following summer.

Although the available statistics leave much to be desired, they demonstrate beyond dispute that only once during the memory of men now living or of their fathers or grandfathers have bluefish been common anywhere in the Gulf of Maine, but that they were extremely abundant as far north as Cape Ann for a period of over 20 years. The disappearance of bluefish from Massachusetts Bay was part of a general shrinkage of the bluefish stock inhabiting our northern waters east of New York as a whole, so pronounced that while the New England catch (Massachusetts, Rhode Island, and Connecticut) ran about 3,000,000 pounds annually in the early eighties, it was but little more than 1,000,000 in 1889, had fallen to 689,160 by 1902, showed a steady decline from then until 1906, and was only about 34,000 pounds in 1919. From time to time during this period, however, there have been exceptionally good seasons when great numbers of bluefish have appeared off southern New England to interrupt this ebb. In 1908, for example, they were more plentiful in Vineyard Sound than for many years, while in 1901 a school 4 or 5 miles long was reported in Narragansett Bay. Apparently it is only in the northern part of its range that the bluefish has diminished notably in numbers.

The bluefish never has supported a fishery of any magnitude in the Gulf of Maine—perhaps never will. Nevertheless its presence or absence there is a matter of direct importance to the fishing interests, for when it swarms it may actually drive away the mackerel, if not the herring and menhaden. While it is now many years since bluefish have been plentiful enough north of Cape Cod to matter one way or the other, history will no doubt repeat itself sooner or later and these sea pirates will again invade the Gulf in abundance, probably for several summers in succession.

Habits.—The bluefish travels in schools, mostly near the surface, and is perhaps the most ferocious and bloodthirsty fish in the sea, leaving in its wake a trail of dead and mangled mackerel, menhaden, herring, alewives, etc., on all of which it preys. As Goode, et al. (1884, p. 574), long ago wrote in their vivid and oft-quoted account

of its destructive habits, the bluefish "not content with what they eat, which is itself of enormous quantity, rush ravenously through the closely crowded schools, cutting and tearing the living fish as they go." Not only the schooling fish, but scup, squeteague, hake, butterfish, cunners, and in fact small fish of all kinds, as well as squid, fall prey to them. Baird estimated that in the early seventies, when bluefish were at the height of their abundance, they annually destroyed at least twelve hundred million fish during the four summer months off southern New England alone; and while from the nature of the case no such calculation can claim even an approach to accuracy, it will at least help give the reader a graphic realization of the destruction they wreak during their periods of plenty. They are also known to eat various Crustacea and even marine worms on occasion, and the young "snappers" 6 to 8 inches long feed largely on copepods, crustacean and molluscan larvæ, as well as on fish fry smaller than themselves.

Bluefish are creatures of warm water. In the years when they pass Cape Cod they usually appear in Massachusetts Bay about the middle and sometimes as early as the 1st of June,[7] and are seen off and on all summer. Most of them depart late in September, but an occasional fish lingers into late autumn. Bluefish have even been caught about Provincetown as late as December. It is not known where these northern bluefish winter, nor even whether they migrate southward along shore or move out to sea.

No fully ripe bluefish have ever been taken so far as we can learn, although females containing large ova approaching ripeness are often seen in summer on various parts of the American coast. While their spawning grounds are still to be discovered, it is not likely that they spawn in inshore waters along the New England coast, and though they may do so along the shores of the Middle and South Atlantic States, we incline to the view now generally held that the chief production of eggs takes place out at sea before the fish appear on the coast. The possibility is still open, however, that the buoyant eggs with segmented yolk and large oil globule from Newport, R. I., provisionally referred to the bluefish by Agassiz and Whitman (1885), were actually those of this species, and while the identity of their "bluefish" larvæ has likewise been questioned, we believe that their identification of the oldest (9 mm.) was correct, though the younger ones may have belonged to some Scombroid.

At this stage the second dorsal fin is formed, the first, however, still represented by the rudiments of the future spines. The anal fins are visible, also, and the tail is slightly forked. These larvæ, like mackerel (which they much resemble), have large blue eyes and large projecting teeth, but they are as far advanced in development as mackerel twice as large, and in proportion to their size they are as ferocious as the adult bluefish are, devouring all other small animals kept in the tank with them.

The bluefish fry of three-fourths to 3 inches, which have often been taken along shore in summer not only south of Cape Cod but even in the Gulf of Maine (p. 240), are presumably the product of that spring's spawning, and it seems that

[7] Along southern New England they are expected during the last half of May.

they grow to a length of 4 to 9 inches by autumn, fish of that size being common in October, while general experience suggests a length of 8 to 12 inches by the following spring. The growth of the older fish has not been followed,[8] nor is the age at which the bluefish matures known.

THE MARIPOSAS. FAMILY LAMPRIDÆ

93. Opah (*Lampris luna* Gmelin)

MOONFISH; JERUSALEM HADDOCK

Jordan and Evermann, 1896–1900, p. 954.

Description.—The opah is notable for the large number of its ventral fin rays, of which there are 14 to 17 (no mackerels, swordfishes, pompanos, bluefish, or

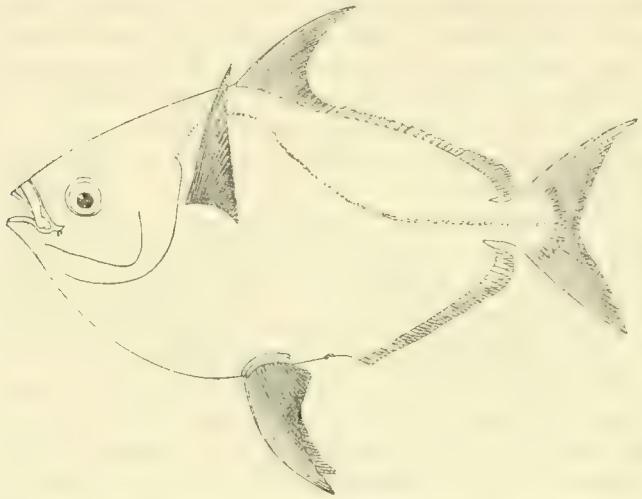

FIG. 113.—Opah (*Lampris luna*)

butterfish have more than 8). There is only one (soft) dorsal fin. The flat, deep (only about one and one-fourth times as long as deep) form of the opah, with the moderately slender caudal peduncle (which is not keeled) and rather pointed snout, suggests an enormous butterfish, but it is provided with very long falcate ventral fins, whereas the butterfish lacks ventrals. The anal (38 to 41 rays) and dorsal fins (53 to 55 rays) are relatively higher than in the latter, and its tail fin is but slightly emarginate instead of deeply forked. The opah, furthermore, is toothless. We may also note as characteristic that the mouth is very small, the pectorals unusually long and pointed, with their bases horizontal instead of vertical, the dorsal very high in front and deeply emarginate in outline, and the anal only about half as long as the dorsal and of nearly even height from front to rear. Both the dorsal and the anal fins extend back close to the base of the caudal, and both are depressible in grooves. The scales are minute.

[8] No growth studies based on the scales or on other exact methods have been undertaken for the bluefish.

Color.—We have never seen this fish alive, but it is described as very beautiful, dark steel blue above shading into green with silver, purple, gold, and lilac luster on the sides and rosy on the belly, with vermilion fins, while the whole body is speckled with silvery and milk-white spots.

Size.—The opah grows to a length of 3 to 6 feet; usually 3 to 4 feet.

General range.—Open waters of the Atlantic and Pacific Oceans. Recorded off the Madeiras, Scandinavia, the British Isles, Norway, Iceland, Newfoundland, Nova Scotia, Maine, and Cuba.

Occurrence in the Gulf of Maine.—We include the opah here because it is said to have been taken off Maine.[9] We find no more definite record of it within the Gulf of Maine, but one was caught off Sable Island in 1856 and a second off La Have Bank many years ago.

Habits.—The opah is usually spoken of as a deep-sea fish, but this is a misnomer, for off Madeira, where it is taken in some numbers, it is caught on hook and line at 50 to 100 fathoms depth only. Being so rare off our coast we need merely note that it feeds chiefly on squid, isopods, and small fish, as well as on seaweeds; that it is an excellent food fish; and that nothing is known of its breeding habits.

THE RUDDERFISHES. FAMILY CENTROLOPHIDÆ.

94. **Barrelfish** (*Palinurichthys perciformis* Mitchill)

LOGFISH; RUDDERFISH; BLACK PILOT

Jordan and Evermann, 1896–1900, p. 964.

Description.—The reduction of the spinous portion of the dorsal fin of the barrelfish to 6 to 8 short detached spines, each with a small triangular fin membrane, closely followed by a large soft-rayed dorsal fin, marks it off from all other Gulf of Maine fishes except certain of the pompano tribe. There is no danger of confusing it with any of the latter, its caudal fin being only slightly emarginate instead of deeply forked and its caudal peduncle moderately stout and without keels instead of very slender. While it suggests a cunner in general appearance, especially in its rather stout body (about two-fifths as deep as long, not counting the caudal), bluntly rounded nose, convex profile, and small mouth, its rudimentary spiny dorsal is a ready field mark to distinguish it from the latter. The soft dorsal fin (20 to 22 rays) rises about midway from tip of snout to base of caudal; the ana (16 or 17 rays) is somewhat farther back. Both these fins are moderately high and taper slightly from front to rear. The anal is preceded by three short spines so nearly imbedded in the skin as to be hardly visible. Both the ventrals and the pectorals are large with rounded tips. The top of the head is scaleless but the body is clothed with small rounded scales.

Color.—Described as varying from blackish to green, and either as dark below as above or paling to bluish white on the belly, variously mottled with darker dots and bars. It is said to change color to accord with its surroundings.

[9] Goode and Bean, 1896, p. 223.

Size.—Maximum length 10 to 12 inches but most of those seen are smaller.

General range.—Atlantic coast of North America, Cape Hatteras to Nova Scotia; most abundant south of Cape Cod.

Occurrence in the Gulf of Maine.—Although the barrelfish is rather common along the outer coast of Nova Scotia on the one hand, and even more so off Woods Hole and thence westward along the southern New England coast on the other, it is so rare a fish within the Gulf of Maine that we have never seen it there ourselves, nor has Doctor Kendall found it on his various collecting trips along the Maine coast. In fact the only definite Gulf of Maine records we have been able to find are one from Boston Harbor, one from Salem, one from Annisquam, and one vaguely described as from the fishing banks off the coast of Maine. Our own experience with this fish is limited to a single occasion, south of Nantucket, when several were seen about a drifting box. They owe their common name to their habit of congregating about floating spars and planks or any drifting wreckage, or inside of barrels or boxes,

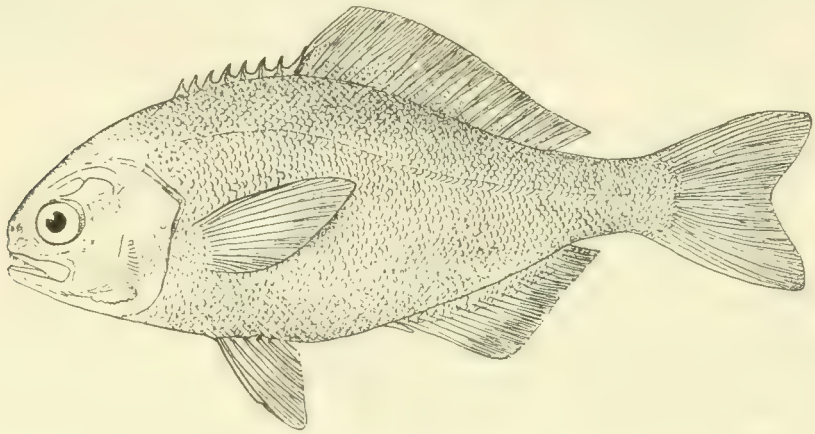

FIG. 114.—Barrelfish (*Palinurichthys perciformis*). After DeKay

where it is easy to catch them in dip nets. Off southern New England they are often found in gulfweed. They sometimes gather about slow-moving vessels, and so closely do they cling to these refuges that one has even been known to cross the Atlantic to Penzance Harbor, in Cornwall, presumably drifting in the packing case in which it was found.

Food.—Barrelfish feed on the sundry small crustaceans, barnacles, hydroids, young squids, small mollusks, and Salpæ which they find near or attached to their floating homes; likewise on ctenophores and on fish fry, the diet lists of specimens taken at Woods Hole including herring, mackerel, menhaden, launce, scup, and silversides.[10] Sometimes they contain seaweed, but we suspect this is eaten for the animals attached to it and not from a vegetarian taste.

Habits.—Nothing is known of the breeding habits of the barrelfish.

[10] Vinal Edwards's notes.

THE BUTTERFISHES. FAMILY STROMATEIDÆ

The members of this family are deep bodied and very much compressed, with one long dorsal fin that is soft rayed except for a few short weak spines at its anterior extremity, an anal of corresponding size and shape, a deeply forked caudal, a blunt nose, and a small mouth. The two species occurring on the east coast of North America lack ventral fins, but the extremity of the pelvic bone projects through the skin as a spine—easily felt but so short that it is apt to be overlooked.

Two species occur in the Gulf of Maine—one (the butterfish) being a common summer visitor, and the other (the harvestfish) a rare stray from the south.

KEY TO GULF OF MAINE BUTTERFISHES

1. The anterior one-fourth of the anal fin is at least seven times as high as the rear portion of the fin. The anal and dorsal fins are both extremely falcate in outline..Harvestfish, p. 250
   The anterior one-fourth of the anal fin is only about 2 or 3 times as high as the rear portion of the fin. The margins of the anal and dorsal fins are only slightly concave ..... Butterfish, p. 245

95. **Butterfish** (*Poronotus triacanthus* Peck)

DOLLARFISH; SHINER; SKIPJACK; SHEEPSHEAD; HARVESTFISH; PUMPKINSEED

Jordan and Evermann, 1896–1900, p. 967.

Description.—The most distinctive characters of the butterfish are its very flat deep body (the fish is only about two and one-third times as long as deep) like a flounder on edge, the only common Gulf of Maine species of this shape combined with a single, long, soft-rayed dorsal, an almost equally long anal, and a deeply forked tail, but *no* ventral fins. The absence of ventral fins separates it from the deep-bodied pompanos; the spineless dorsal and deeply forked tail from the scup (p. 263) and John Dory (p. 291); the lack of detached dorsal spines from the triggerfishes, which are, furthermore, very different in general aspect (p. 293); and it is easily distinguishable from its rare relative, the harvestfish (p. 250), by the fact that its dorsal and anal fins are much lower (compare fig. 115 with fig. 117). The dorsal (about 45 rays) originates close behind the axil of the pectoral and tapers at first abruptly and then gradually backward, while the anal (about 38 rays) narrows evenly from front to rear. There is a short forward-pointing spine close in front of each of these fins, and both extend rearward almost to the base of the caudal.

Distinctive, also, are the long-pointed pectoral fin, the short head, the blunt snout, the small mouth, the weak teeth, and the short and slender unkeeled caudal peduncle. The scales are very small and easily detached when the fish is handled, and there is a row of very conspicuous mucus pores below the anterior half of the dorsal fin.

Color.—Leaden bluish above, paling on the sides, with silvery belly.

Size.—The largest are about 10½ inches long; the run about 6 to 8 inches.

General range.—Atlantic coast of North America from Nova Scotia to the Gulf of Mexico.

Occurrence in the Gulf of Maine.—This is a regular summer visitor to the Gulf of Maine, locally common along the shores of Massachusetts and Maine; common, also, on the Nova Scotian side of the Bay of Fundy but appearing only irregularly and in small numbers on the New Brunswick shore, though it has been taken repeatedly in Passamaquoddy Bay.

The numbers of butterfish diminish, passing from west to east along the northern coast line of the Gulf, as is illustrated by the fact that in 1919, a fairly representative year, more than 180,000 pounds were caught in Plymouth and Barnstable Counties (both sides of Cape Cod), 20,000 pounds along the short coast line of Essex County, Mass., and about 31,000 pounds thence to and including the Casco Bay region, which seems to be a regular center of abundance for it, but less than 1,000 pounds between Casco Bay and Penobscot Bay. So few were taken east of the latter, in spite of the many weirs maintained along that part of the coast for the sardine fishery, that none were mentioned thence in the fishery statistics for the year in question.

FIG. 115.—Butterfish (*Poronotus triacanthus*)

Butterfish also appear on Georges Bank in summer, sometimes in comparative abundance, and about 1,000 fish were taken there during one trawling trip in 1913; but although they are said to be common as far east as Canso [11] (hence probably all along the outer coast of Nova Scotia), we have heard no rumor of them on Browns Bank, nor are they known to occur in the central deeps of the Gulf of Maine.

Season.—Butterfish usually appear off Rhode Island by the middle or end of April and are seen about Woods Hole as early as the middle of May, but they are not abundant there until a month later, nor do they appear in Massachusetts Bay in any numbers until well into June, and it is not until the end of that month or the first part of July that they are plentiful anywhere north of Cape Cod. They stay in the Gulf of Maine all summer, to disappear thence in autumn. Probably they leave its northern parts earlier than they do its southern parts, and though

[11] Cornish. Contributions to Canadian Biology, 1902–1905 (1907), Ottawa.

the precise date of their departure is not known, they probably linger in the southern part of the Gulf until November, as they do about Woods Hole and off Rhode Island. During the season of 1913 the first butterfish were reported on Georges Bank, June 5 to 8. A few were caught in October and the latest (82 fish) from November 21 to 27.

Habits.—Considering how familiar and valuable this fish is, surprisingly little is known of its manner of life. As a rule it travels in small bands or loose schools, commonly coming close inshore into sheltered bays and estuaries—hence its frequent capture in pound nets and the like—and showing so decided a preference for sandy rather than rocky or muddy bottoms that in even as small an area as Duxbury Bay, for example, very few are taken in such traps as are situated on muddy ground while others located along the sandy beach near by yield considerable numbers. General experience is to the effect that the butterfish keeps chiefly to shoal (often very shoal) water during its stay, and schools are often seen close to the surface. At Cohasset (on the south side of Massachusetts Bay), for instance, schools of butterfish fifty to a few hundred strong are often to be seen where the flats are covered by only 4 or 5 feet of water, and although definite evidence is lacking we believe butterfish seldom descend deeper than 15 to 30 fathoms during the summer, but that the fish caught by the otter trawlers on Georges Bank are picked up by the trawl on its way up or down—not while it is dragging on bottom. In fact, mackerel fishermen often take a few butterfish there in their purse seines. Although it seems well established that the butterfish actually withdraw from the Gulf when they disappear at the approach of autumn, their winter home is unknown.

Food.—The butterfish feeds on small fish, squid, Crustacea such as amphipods and shrimp, annelids, etc., and ctenophores have been found in butterfish stomachs at Woods Hole, though these watery objects are not a regular item in its diet.

Breeding habits.—Butterfish begin spawning in the Gulf of Maine soon after their arrival in June. The height of the reproductive season is in July and their eggs have been taken throughout August. Observations made at Woods Hole suggest that butterfish do not spawn close inshore but some few miles out at sea, returning to the coastwise waters when spent.[12] Judging from the occurrence of the adult butterfish it would not be surprising to find its eggs anywhere off the New England and western Nova Scotian coasts or on the Scotian side of the Bay of Fundy, Huntsman having found large spawning individuals in St. Mary Bay in July, and we have actually taken them in our tow nets at several stations in Massachusetts Bay and off Cape Cod. But in spite of the considerable number of butterfish eggs produced in the Gulf of Maine, we doubt whether the latter is a favorable nursery for this fish, for we have taken its larvæ only twice in the Gulf of Maine—off Cape Cod on August 16 and on Georges Bank on July 23, 1916, a total of only 3 specimens, 5 to 30 mm. long—although we have made hundreds of hauls widely distributed inshore as well as offshore at the season when they might be expected. Young butterfish have never been reported from the Bay of Fundy, but by contrast butterfish fry are very plentiful along the shores of southern New England.

[12] Kuntz and Radcliffe, 1918, p. 112.

The eggs are buoyant, transparent, spherical, and 0.7 to 0.8 mm. in diameter. There is usually a single oil globule of about 0.17 to 0.2 mm. In newly spawned eggs, however, there may be two globules, which coalesce as development advances.[13] At a temperature of 65°—the summer state of the surface of Massachusetts Bay—incubation occupies less than 48 hours. It is probable that development can only proceed in comparatively warm water, though the lower temperature limit to successful reproduction is not known. The larvæ are about 2 mm. long at hatching, comparatively stout, with the vent situated far forward on one side and considerably above the margin of the finfold, and with large black chromatophores scattered over head and trunk. By the third day after hatching, when the larva is about 2.3 mm. long, the yolk is absorbed and the pigment has gathered in four characteristic patches—one on the nape, one in the dorsal region of the abdominal cavity, one on the dorsal side and one on the ventral side of the trunk behind the vent. Dorsal, anal, and caudal fin rays are visible in larvæ of 6 mm., when the body has already begun to assume the deep compressed form so characteristic of the adult butterfish. At a length of 15 mm. the caudal fin is deeply forked, the unpaired fins are formed, and the little fish resembles the adult sufficiently for ready identification.[14]

During their first summer young butterfish, like young haddock, often live in the shelter of the larger jellyfishes, and Goode (1888, p. 222) graphically described the fry of 2 to 2½ inches as swimming among the tentacles of Cyanea (10 or 15 little fish under one Medusa), where they find protection from larger fish but to which they sometimes fall prey. This association, however, is not essential to their welfare, for fry are often seen living independently at the surface, particularly in sheltered bays west and south of Cape Cod, and we have found no young butterfish with the many Cyanea that we have captured in the Gulf of Maine.

It seems that the fry that are hatched earliest in the season grow to a length of 3 to 4 inches by autumn, great numbers of that size having been taken in Rhode Island waters in October, but late-hatched fish are probably not more than 2 to 3 inches long at the beginning of winter, and they can grow little during the cold season, for little fish of 3 to 5 inches are seen again in the spring. A series of measurements made by Welsh at Atlantic City, N. J., in August, 1921, throws some light on the subsequent rate of growth. The fish fell into two groups—one ranging from 4 to 5¼ (and averaging about 4¾) inches and the other from 7½ to 10½ inches. Probably those of the first group (which were much the more numerous) were in their second summer and those of the second size group in their third or perhaps fourth summer. These measurements suggest, furthermore, that some may mature when 1 year old and that all do so when 2 years old.

Butterfish are caught in pounds, traps, weirs, a few in gill nets, seines, and otter trawls. We have never heard of one biting a hook.

[13] A large series of butterfish eggs artificially fertilized at Gloucester hatchery have been available for comparison with the pelagic eggs taken in the tow nets.

[14] Kuntz and Radcliffe (1918, pp. 112–116, figs. 58–68) give a full account of the embryology and larval development of the butterfish.

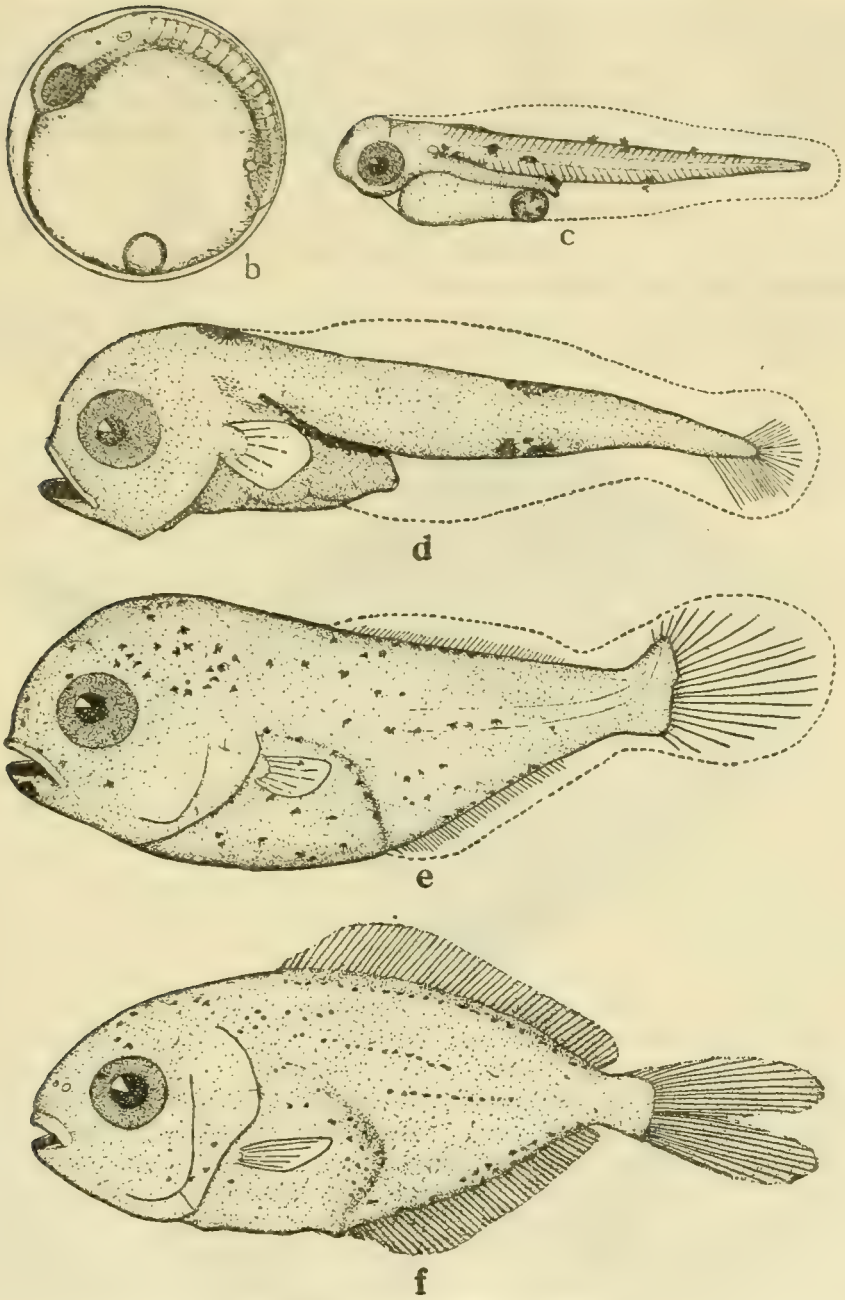

FIG. 116.—Butterfish (*Poronotus triacanthus*)

b, Egg. *c*, Larva, 1 day old, 2.1 millimeters. *d*, Larva, 3.2 millimeters. *e*, Larva, 6 millimeters. *f*, Fry, 15 millimeters.

Commercial importance.—This is one of our very best table fish, fat, oily, but of delicious flavor. First-hand experience with many a one fresh from the net as well as on the table proves the old tale that butterfish have a peculiar nauseous odor to be a myth. However, they often served as manure during the first half of the past century, and appreciation of the fact that they are too good for this use is of such recent growth that even to-day the demand for butterfish in Boston is uncertain and price widely variable.

96. **Harvestfish** (*Peprilus paru* Linnæus)

STARFISH; PAPPYFISH

Jordan and Evermann, 1896–1900, p. 965.

Description.—This is an even deeper fish than the common butterfish, the body (not counting the caudal peduncle) being almost as deep as long, ovate in outline,

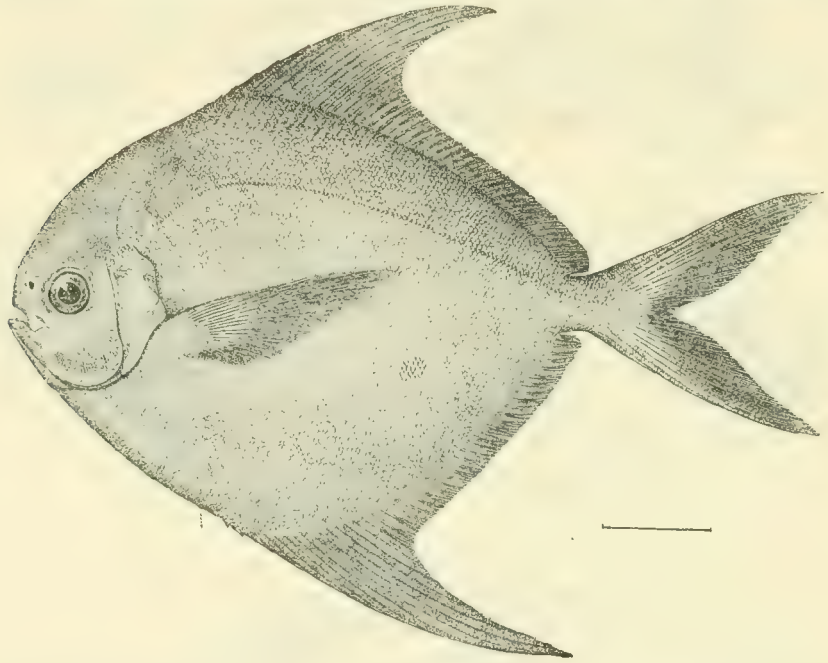

FIG. 117.—Harvestfish (*Peprilus paru*)

its nose rounded, its mouth very small, and its head very short. The outline of the dorsal and anal fins affords the readiest field mark to separate it from its relative, the butterfish, both being very high and falcate in front, narrowing farther back (compare fig. 117 with fig. 115). The mucus pores, so conspicuous in the butterfish, are lacking in the harvestfish. There is also a color difference between the two, the latter being described (we have no color notes from life) as greenish above and golden yellow below. In all other respects, including size, it so closely resembles the butterfish that no further account is called for.

General range.—West Indies and south and middle Atlantic coasts of North America; rarely north to Cape Cod.

Occurrence in the Gulf of Maine.—This southern fish was taken at Monomoy Point by Dr. W. C. Kendall, in 1896, which is its only Gulf of Maine record.

THE SEA BASSES. FAMILY SERRANIDÆ

The sea basses are an extremely numerous tribe of perchlike fishes, with both spiny and soft-rayed portions of the dorsal fin well developed, and either separate or at least divided by a deep notch. The ventrals are thoracic in position and situated under the pectorals. The anal fin is nearly or quite as long as the soft part of the dorsal; the caudal peduncle is deep and the tail is broad. The anal fin is preceded by several stout spines, the margin of the gill cover bears one or two sharp conical spines, and when the mouth is closed the maxillary bone is not sheathed nor hidden by the preorbital bone. Smooth cheeks are a ready field mark to distinguish any of the sea basses from the rockfish family (p. 304); long anal fin relative to the soft dorsal distinguishes it from the croaker family (p. 269); spiny gill cover from the porgy family (p. 262); and large mouth from the cunners (p. 280).

KEY TO GULF OF MAINE SEA BASSES

1. With a single continuous dorsal fin—its front half spiny, its rear half soft rayed ---------- Sea bass, p. 259
   Two separate dorsal fins—the first spiny, the second soft rayed ---------- 2
2. The two dorsal fins are separated by a distinct space; there are two sharp spines on the margin of each gill cover; the sides are distinctly striped ---------- Striped bass, p. 251
   The two dorsal fins meet at their bases; there is only one sharp spine and one blunt angle on the margin of the gill cover; the sides are not distinctly striped -- White perch, p. 257

97. **Striped bass** (*Roccus lineatus* Bloch)

ROCKFISH; ROCK; SQUID HOUND

Jordan and Evermann, 1896–1900, p. 1132.

Description.—No one character alone characterizes the striped bass, but the combination of fin structure and arrangement with general outline and structure of the jaw. Its rather deep and keelless caudal peduncle, stout body, the presence of two well-developed dorsal fins (spiny and soft rayed and of equal length), the lack of dorsal and ventral finlets, and a tail but slightly forked, mark it off from all mackerels, swordfish, bluefish, and pompanos. The fact that its anal fin is almost as long as the second dorsal and (less obvious) that its maxillary (upper jaw) bones are not sheathed by the preorbital bone, separate it from all the weakfish tribe (p. 269). Nor is there any danger of confusing it with the sea bass, cunner, tautog, or rosefish, for its two dorsal fins are quite separate whereas in all these the spiny and soft-rayed parts are confluent. Closest to it in general appearance is the white perch, but the two dorsal fins of the latter are so close together that there is no free space between them (p. 257), and its spines are stiffer. Furthermore, there are two sharp spines on the margin of the gill cover of the striped bass and only one, a blunt angle, in the perch.

The striped bass is moderately elongate (three to four times as long as deep), stout, its back hardly arched, but sway bellied, with moderately stout caudal peduncle, long head (almost as long as the fish is deep), oblique mouth gaping

back to the eye, moderately pointed nose, and projecting lower jaw. Young fish are more slender than old. The two dorsal fins are about equal in length, the first (9 stiff spines) triangular in outline, originating over the middle of the pectoral; the second (14 soft rays) is regularly graduated in height from front to rear, and separated from the first by a distinct though short space. The anal (about 11 rays preceded by 3 spines) is of about the same size and form as the second dorsal, and originates below the middle of the latter. The caudal is moderately long and only slightly forked. The pectorals and ventrals are of moderate size, the latter somewhat *behind* the former.

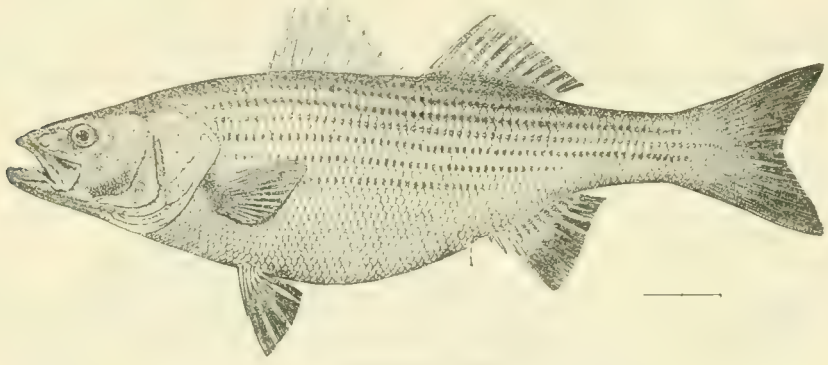

FIG. 118.—Adult

FIG. 119.—Larva, 5 millimeters

STRIPED BASS (*Roccus lineatus*)

Color.—Dark olive green varying to blue above, paling on the sides, and silver on the belly, sometimes with brassy reflections. The sides are barred with seven or eight narrow, black, longitudinal stripes, which follow as many rows of scales and which may be variously interrupted. The highest stripe is the most distinct, and all of them but the lowest are above the level of the pectoral fins.

Size.—The bass grows to a great size, the heaviest of which we have found definite record being several of about 125 pounds taken at Edenton, N. C., in April, 1891.[15] One of 112 pounds, which must have been at least 6 feet long, was caught at Orleans, Mass., many years ago, while fish of 50 to 75 pounds are not exceptional, but the usual run of those caught weigh only 3 to 30 pounds, and the average weight of the bass recorded in the register of the former Glades Hotel[16] at Scituate, Mass., during the period 1854 to 1858, was about 27 pounds. A bass 3 feet long weighs about 18 pounds.

[15] Smith. North Carolina Geological and Economic Survey, Vol. II, 1907, p. 271. Raleigh.

[16] Kindly lent by Mr. John Adams.

General range.—Atlantic coast of North America from the Gulf of St. Lawrence to the Gulf of Mexico, running up into fresh water to spawn.

Occurrence in the Gulf of Maine.—The striped bass is distinctly a coastwise fish and seldom found at sea more than a mile or two out from land. It is equally at home in salt, brackish, or fresh water. Furthermore, as its abundance in the Gulf of St. Lawrence proves, temperatures even lower than those of the Gulf of Maine are no barrier to it. At the time of the settlement of New England it was a very familiar fish in sheltered bays, estuaries, off sandy beaches, and about rocky headlands all along the coasts of the Gulf of Maine from Cape Cod to and including the Bay of Fundy. So plentiful was it, and so easy to capture, thanks to its large size and its habit of coming into the mouths of streams and creeks, that it yielded an important food supply to the early settlers.

Wood (1634, p. 37) tells us that in what is now part of Boston Harbor "The basse is one of the best fishes in the country, and though men are soone wearied with other fish, yet are they never with basse. It is a delicate, fine, fat, fast fish, having a bone in his head which contains a saucerfull of marrow sweet and good, pleasant to the pallat and wholesome to the stomach. * * * Of these fishes some be three and four foote long, some bigger, some lesser; at some tides a man may catch a dozen or twenty of these in three houres. The way to catch them is with hooke and line, the fisherman taking a great cod line to which he fasteneth a peece of lobster and threwes it into the sea. The fish biting at it, he pulls her to him and knockes her on the head with a sticke. These are at one time (when alewives pass up the rivers) to be catched in rivers; in lobster time at the rockes; in mackerel time in the bays; at Michaelmas [September 29] in the sea. When they use to tide in and out of the rivers and creekes the English at the top of an high water do crosse the creekes with long seanes or basse nets, which stop in the fish; and the water ebbing from them they are left on the dry ground, sometimes two or three thousand at a set, which are salted up against winter, or distributed to such as have present occasion either to spend them in their homes or use them for their grounds."

Wood (1634, p. 47) also describes "shoales of basse have driven up shoales of mackerel from one end of the sandie beach to the other," near Salem, and mentions them in the Merrimac. In fact, in early days there were more or less bass about every river mouth tributary to the Gulf, except possibly on the west Nova Scotian coast, where we find no mention of them. As far back as the record runs the chief centers of abundance for bass within the Gulf were Cape Cod Bay and the shores of Cape Cod, the neighborhood of Boston Bay, the various bays and sounds near the Kennebec River, and the larger rivers that drain into the Bay of Fundy.

In the nature of things no large fish with a geographic range so narrow can compare in abundance with such offshore species as herring, haddock, cod, etc., a rule to which the bass was no exception. Inexhaustible though the supply seemed in certain restricted localities, a decrease was reported as early as the last half of the eighteenth century. At first this was apparent only locally. For example, very few bass were seen in the Piscataqua after about 1792, though an odd bass was caught there as recently as 1880. They seemed to have

continued plentiful in Massachusetts Bay during the first half of the nineteenth century when small bass were still being netted in abundance along the beaches between Boston Harbor and Cohasset, while the bass fishery of Cape Cod Bay was still so productive that 300 good-sized fish were taken at one seine haul at the mouth of Barnstable Harbor in July, 1829. Seven hundred were taken in a day at Provincetown as recently as October, 1859. In those days bass fishing in the surf with hook and line was as well recognized a sport at various beaches about Massachusetts Bay as it now is on the middle Atlantic coast of the United States; but even as long ago as 1862 Freeman (in his history of Cape Cod) wrote that these fish were far less plentiful than of old, and it is now many years since we have heard of a bass caught on hook and line in Massachusetts Bay; while for the past quarter century, at least, they have been so rare in the inner parts of the bay that the capture of even a single fish there by any method has been an unusual event. Thus, none at all were reported (though odd fish may perhaps have been taken) from Essex County during the period 1903 to 1910, nor in 1919. As appears from the following table of returns from the traps, bass have never fallen to quite as low an ebb as this along Cape Cod or in Cape Cod Bay, but even there, and in the best years, the annual catch has long been negligible from the commercial standpoint.

Catch of bass in the Massachusetts Bay—Cape Cod region from 1896 to 1921 [1]

Year	Boston to Monomoy	Boston to Cape Ann	Year	Boston to Monomoy	Boston to Cape Ann
	Pounds	*Pounds*		*Pounds*	*Pounds*
1896	43	0	1907	136	0
1897	3,734	0	1908	22	0
1898	124	13	1909	14	0
1899	25	12	1910	54	0
1900	51	9	1911	17	0
1906	83	0	1921	4,756	0

[1] These figures are only approximate.

The years 1897 and 1921 stand out as notable exceptions when bass were more plentiful locally than for many years previous. In the former year the catch was chiefly from Provincetown; in the latter all but one or two of the fish were from the close proximity of the mouth of the Cape Cod Canal at Sandwich, which was opened a few years previous and through which the bass in question may have worked. A considerable number of small bass, which did not find their way into the official returns, were also taken in the inlets along the outer shore of Cape Cod in 1921 or the year previous.

We have not been able to learn whether any bass still linger about the mouth of the Merrimac River. A number were seined there in 1892 but only an odd fish in 1897,[17] while they have certainly been scarce there since the middle of the past century. Although the extensive series of salt and brackish estuaries and creeks on either side of its mouth might seem excellent bass water, there is nothing in the early accounts to suggest that bass were ever as plentiful thereabouts as in Boston

[17] One small fish seined at East Haverhill.

Bay, on the one hand, or near the Kennebec River, on the other; and while the shore fisheries of the State of New Hampshire yielded 850 pounds of bass in 1889, none at all were reported thence in 1919.

Turning now to the Maine coast, there is ample evidence that in old days bass were plentiful in and about most of the river mouths west of the Penobscot but less so in those to the east. For instance, they were so numerous in the Kennebec and in the shallow and partly inclosed bays and beaches near its mouth that 1,000 pounds have been taken there on a single tide as recently as 1830, but bass were practically gone from the Androscoggin River by 1860, and by 1880 the stock of Maine bass had so diminished that the year's catch from the Kennebec River had fallen to 12,760 pounds, with 8,000 pounds coming from the Sheepscot River and a few from the St. Croix, the Penobscot, and Casco Bay, a total catch of only 26,000 to 27,000 pounds for the entire coast of the State. Ever since then bass have so constantly grown more and more scarce off the coast of Maine that the catch for the entire State had dropped to 15,715 pounds by 1902, all taken in and about the mouths of the Kennebec and Sheepscot Rivers except for two hundred and odd pounds picked up south of Cape Elizabeth. In 1905 only 4,200 pounds were reported, all from Kennebec-Sheepscot waters, while in 1919 the total catch of bass for the State was only about 600 pounds, nearly all from the Kennebec.

The stock of bass has maintained itself no better along the Canadian shores of the Gulf of Maine. They were already scarce by 1873 in the St. John, where they had been so plentiful during the first half of the century that bass playing on the surface like porpoises were a familiar sight,[18] and although bass are still found in the estuaries of the St. John so few are caught that they have not been mentioned of late years in the Canadian statistics of the fisheries of the north shore of the Bay of Fundy. A few bass still occur in the large warm estuaries and in the neighboring fresh water of the Shubenacadie and Annapolis Rivers, but only 700 pounds were reported as caught on the Nova Scotian side of the Bay of Fundy in 1919, and none at all along the western shores of Nova Scotia.

Since striped bass have dwindled as nearly to the vanishing point in the St. John (which still sees a bountiful yearly run of salmon) as in the estuaries of rivers that have been dammed or fouled by manufacturing wastes, the chief blame for its present scarcity can not be laid to obstruction of the rivers; and as this is a very vulnerable fish, easily caught, always close inshore, always in shallow water, and with no offshore reservoir to draw on when the local stock of any particular locality is depleted by such wholesale methods of destruction as the early settlers employed (p. 253), overfishing must be held responsible.

Food.—The bass is a very voracious fish, preying indiscriminately on small fish of all kinds—herring, menhaden, shad, smelt, and such small fry as launce, mummichogs, and silversides being its chief diet in inclosed waters—and hunting for crabs, shrimps, lobsters, squid, mussels, and various other invertebrates along open shores.

[18] Adams, 1873 (Fishes, Part 3, pp. 201–257).

Habits.—Striped bass are resident throughout the year wherever found except for the spawning migration touched on hereafter. They chiefly frequent shoal estuaries, particularly on weedy bottom, though some—especially the large fish—lie in the surf along sandy beaches or about rocky headlands, islets, and ledges, while others again may run up rivers for long distances.

Bass do not move out to sea in winter as do herring and various other fishes, but remain in the river mouths and estuaries, merely retreating to the deeper reaches, bays, and coves where they are often speared through the ice and netted beneath it, or, if on open coasts, to slightly deeper water. But though more or less sluggish during the cold season, it seems that they do not hibernate but feed when opportunity offers.

Bass of old gathered about our river mouths in June for spawning, though there is no regular run of them comparable to the runs of salmon, alewives, or shad. They are usually described as anadromous—that is, running up fresh rivers to breed—which is true in the sense that they always enter some stream and never spawn in the open sea. Bass often spawn in brackish water, however, and most of them do so in the lower reaches. According to latitude bass spawn late in spring and early in summer, the available evidence pointing to June as the height of the season in the Gulf of Maine.

The eggs (about 3.6 mm. in diameter) are semibuoyant—that is, they sink but are swept up from the bottom by the slightest disturbance of the water—and this is so prolific a fish that a female of only 12 pounds weight has been known to yield 1,280,000 eggs, while a 75-pound fish probably would produce as many as 10,000,000. The eggs hatch in about 74 hours at a temperature of 58°; in about 48 hours at 67°. By autumn the young fry produced in Gulf of Maine waters are 2 to 3 inches long, and of old when bass were still plentiful many of these little ones were netted in winter with smelt and tomcod in the Kennebec and other streams of Maine.[19] In more southern waters where bass commence spawning earlier the fry may be an inch long in June and grow to a length of 4½ inches by October. In captivity they have been known to grow from 6 inches long to 20 inches in the space of 11 months, and while nothing is definitely known of the rate of growth of the older fish in the sea, the fact that bass [20] in a certain pond in Rhode Island have been described as gaining weight from 1 pound in June to 6 pounds in October suggests that they increase very rapidly in size when food is plentiful.

The age at which the bass matures is not known, but they are certainly long lived, for one kept in the New York Aquarium lived to an age of about 23 years.[21]

Commercial importance.—Bass are so rare in the Gulf of Maine that they are no longer of importance there either to commercial fishermen or to anglers. West and south of Cape Cod, where they are more plentiful, their excellence as a food and game fish is proverbial. Bass are taken in gill nets, stop nets, seines, traps, and pounds, and are caught about rocks, in the surf, and in estuarine waters on hand lines and with rod and reel.

[19] Atkins (1887) gives much information as to the former status of bass in the rivers of Maine.

[20] Bean, 1903.

[21] Bulletin, New York Zoological Society, Vol. XVI, No. 60, November, 1913, p. 1049.

98. White perch (*Morone americana* Gmelin)

SEA PERCH

Jordan and Evermann, 1896–1900, p. 1134.

Description.—The white perch closely resembles its larger relative, the striped bass, in its general form, especially in the deep keelless caudal peduncle and in the number, outline, and arrangement of its fins. It is a deeper fish, however (only about two and two-thirds times as long as deep, not counting the caudal), and more compressed, almost as thin, in fact, as a butterfish (p. 245). The dorsal profile of its body is more convex than is that of a bass but that of its head is concave and its mouth is smaller. Furthermore, the two dorsal fins of the white perch are confluent while in the striped bass they are separated by an interspace; its anal rays are less

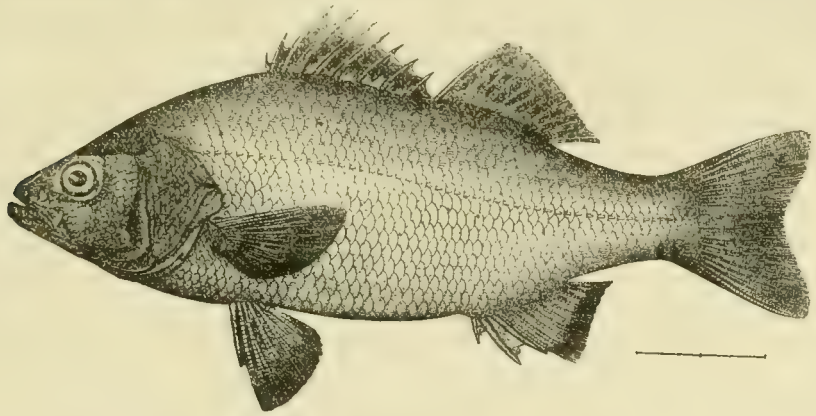

FIG. 120.—Adult

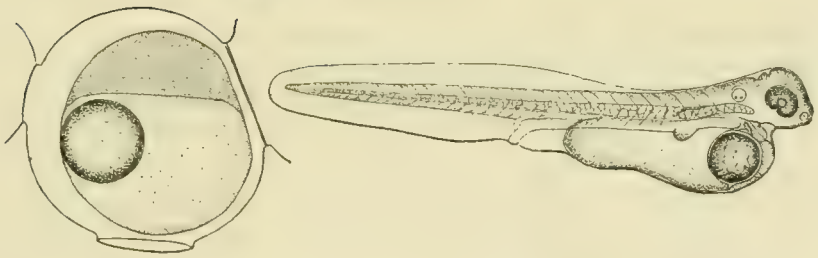

FIG. 121.—Egg

FIG. 122.—Larva, 6 days old, 8 millimeters

WHITE PERCH (*Morone americana*)

numerous, the anal spines are much stouter than those of the bass and the second and third are about equal in length (graduated in the bass), and there is only one sharp spine and a blunt angle at the margin of the gill cover of the perch, while there are two spines in the bass. Finally, there is a constant difference in color.

The first dorsal (9 spines) is rounded in outline with its third and fourth spines longest, and although there is no free space between the two dorsal fins they are entirely separated by a deep notch. The second dorsal fin (1 spine and 12 rays) is rhomboid in outline and so short that it leaves bare a long caudal peduncle. The anal fin (9 to 10 rays preceded by 3 stout spines) originates under the middle of the

second dorsal and is of the same shape as the latter. The ventrals originate *behind* the pectorals and each is armed with one stout spine at its anterior margin. Both pectorals and ventrals are larger in comparison with the size of the fish than those of the striped bass.

Color.—The upper surface is variously olive, grayish dark green, or dark silvery gray, shading to paler olive or silvery green on the sides and to silvery white on the belly. The ventral and anal fins are rose-colored at the base. The sides of young specimens are marked with pale longitudinal stripes that fade out with growth.

Size.—White perch are occasionally as much as 15 inches long, 5 inches or more deep, and 2 to 3 pounds in weight, but they average only about 8 to 10 inches and 1 pound or less.

General range. –Atlantic coast of the United States from the Gulf of St. Lawrence and Nova Scotia to South Carolina, breeding in fresh or brackish water and permanently landlocked in many fresh ponds and streams.

Occurrence in the Gulf of Maine.—The white perch inhabits salt, brackish, and fresh water indifferently along the shores of southern New England, but although it is a familiar fish in many ponds throughout northern New England, New Brunswick, and Nova Scotia, very few white perch are found in estuarine situations north of Cape Cod, and it hardly belongs to the fish fauna of the open Gulf. Thus we have not been able to satisfy ourselves of its presence in localities apparently as suited to it as Duxbury Bay or the salt creeks about Cohasset or Marshfield on Massachusetts Bay, and although Storer long ago described white perch as brought to Boston market from the mouths of neighboring rivers and from ponds to which the sea had access, it does not figure in the statistics of the shore fisheries of any part of Massachusetts Bay for 1902, 1905, or 1919. It is certainly as rare along the western and northern coasts of the Gulf, since none were reported from the shore fisheries of Maine in 1905 or 1919, and only 400 pounds in 1902. Apparently it does not occur at all in salt water in the Bay of Fundy.

At rare intervals white perch appear locally in unusual numbers. Casco Bay saw such an event in the summer of 1901 when local fishermen, not knowing the fish, dubbed it "sea bass," and no less than 1,600 pounds of white perch were taken in the shore fisheries of the short coast line of New Hampshire in the year 1912. With the fish so widely distributed inland, similar invasions of sheltered coastal waters from fresh streams draining into them may be expected from time to time. However, there is no reason to suppose that white perch were ever more regularly plentiful along the coast of the Gulf of Maine than they are to-day, nor so far as we can learn has one ever been seen out in the open sea far from land.

Food.—When living in salt or brackish water the habits of the white perch are much like those of the striped bass; it is similarly carnivorous, feeding on small fish fry of all kinds, young squid, shrimps, crabs, and various other invertebrates, as well as on the spawn of other fish, to which it is very destructive. Swarms of young perch, for instance, have been seen following the alewives around the shores of ponds on Marthas Vineyard, eating their spawn as it was deposited. It is a free biter on almost any bait.

Habits.—Perch always keep in shallow water; they are never caught deeper than 3 or 4 fathoms. However, they are not bottom fish but wander from place to place in small schools. Like bass, they are resident throughout the year wherever found. In winter they congregate in the deeper parts of the bays and creeks, where they either hibernate or at least pass the cold season in a sluggish condition.

Breeding.—In southern New England the white perch breeds in April, May, and June. Presumably the season commences a few weeks later in the Gulf of Maine, but no definite data are available on this point. Those living in salt water run up into fresh or slightly brackish water to spawn. The eggs (about 0.73 mm. in diameter, with large oil globule) sink and stick together in masses or to any object on which they chance to rest. In fact, they are so sticky that this is a difficult fish to propagate artificially. Incubation occupies about 6 days at a temperature of 52°. The newly hatched larvæ are about 2.3 mm. long with the vent some distance behind the yolk sac and very little pigment. In five or six days after hatching, the head begins to project forward, the yolk sac has been partly absorbed, and branched pigment cells have appeared on the oil globule. The late larval and post larval stages have not been described.[22]

Commercial importance.—Wherever the white perch is abundant in tide waters it is of considerable commercial importance, for there is no better pan fish. It also affords good sport to many anglers. In neither of these respects, however, does it figure at all in the Gulf of Maine.

99. **Sea bass** (*Centropristes striatus* Linnæus)

BLACK SEA BASS; BLACKFISH

Jordan and Evermann, 1896–1900, p. 1199.

Description.—The sea bass is easily distinguished from its near relatives, the striped bass and white perch, by the fact that the spinous and soft-rayed portions of its dorsal fin are continuous, so that there is but one long fin instead of two short separate fins. In this it agrees with the scup (p. 263), rosefish (p. 304), cunner (p. 281), and tautog (p. 286), but its general form, rounded caudal and pectoral fins, and short but high anal fin are sufficient to separate it from the first, its color obviates all danger of confusing it with the second, while no one should take sea bass for tautog or cunner, its mouth and its pectoral fins being much larger, its caudal of different outline, and the soft portion of its dorsal as long as the spiny portion.

It is moderately stout bodied, about three times as long (not counting the caudal fin) as deep, with rather high back but flat-topped head, moderately pointed nose, a large oblique mouth, eye set high up, and a sharp flat spine near the posterior angle of the gill cover. The spiny (10 spines) and soft (11 rays) portions of the dorsal fin (which originates slightly in front of the rear corner of the gill cover) are separately rounded, the latter much higher than long, with the characteristic outline shown in the illustration (fig. 123). The caudal is rounded in the middle, slightly concave near each corner, with the upper corner considerably prolonged,

[22] Ryder (Report, U. S. Commissioner of Fish and Fisheries, 1885 (1887), p. 518) describes the early development.

and though this last is a trivial character and variable from fish to fish it is an extremely characteristic one shared by no other Gulf of Maine species except the kingfish (p. 277). The anal (3 short sharp spines followed by 7 soft rays) originates under or very slightly behind the origin of the soft portion of the dorsal, which it resembles in its rounded outline and in being much higher than long. Both the anal and the soft part of the dorsal are notably flexible. The pectorals are so long that they reach back to the anal, and are broad and round tipped—a good field mark. The ventrals, too, are larger than in any other fish with which the sea bass might be confused, and they originate *in front* of the pectorals, whereas in scup, rosefish, cunner, and tautog they stand slightly behind the latter. The scales are rather large, but the top of the head is naked.

Color.—Like most fish that lie on rocky bottom sea bass vary widely in color, the general ground tint ranging from smoky gray to dusky brown or almost black, sometimes with a bluish cast and usually more or less mottled. The belly is but slightly paler than the sides. In every sea bass we have seen the bases of the ex-

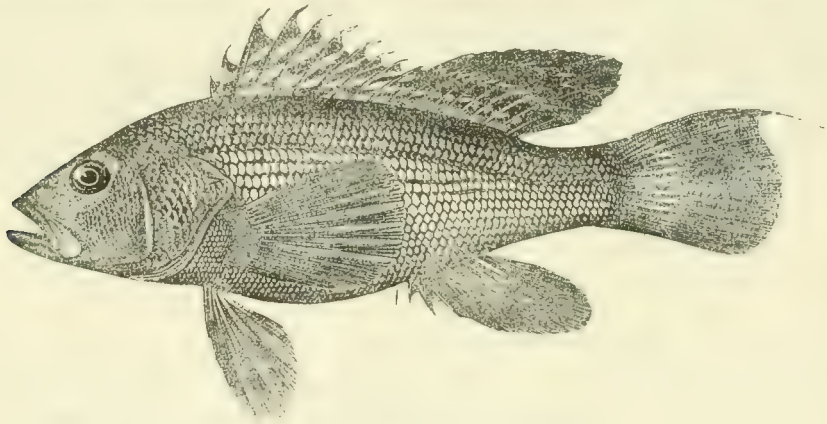

FIG. 123.—Sea bass (*Centropristes striatus*)

posed portions of the scales have been paler than their margins, giving the fish the appearance of being barred with longitudinal series of dots of a lighter tint of brown than the general hue in dark fish; pearl gray in the palest. The dorsal fin has several series of whitish spots and bands; the other fins are mottled with dusky. Young fish are greenish and often show dark cross bars.

Size.—Sea bass grow to a length of 2 feet or longer, and rarely to a weight of 6 pounds or more, but northern specimens are rarely heavier than 4 pounds and they average only about 1½ pounds. A fish a foot long weighs about a pound, while one of 18 to 20 inches weighs about 3 pounds.

General range.—Atlantic coastal waters of the United States, from Florida to Cape Cod and rarely to Maine.

Occurrence in the Gulf of Maine.—The sea bass reaches the Gulf only as a rare stray from the south. Matinicus Island is its northernmost outpost. It has been taken in Casco Bay, near Gloucester (where a few have been caught in the traps), off Nahant, Salem, and Beverly, in Massachusetts Bay, at North Truro, and at

Monomoy, but never, so far as we can learn, has it been found in any numbers north of Cape Cod. We have never seen it ourselves in the Massachusetts Bay region, nor are fishermen of whom we have inquired familiar with it there. "Sea bass," it is true, occasionally appear in the returns of the local pound nets, traps, etc.—80 pounds, for example, at Provincetown in 1896; 146 pounds at Truro in 1898; 101 pounds at the same locality in 1900; with odd fish at Eastham, Barnstable, Sagamore, Manomet, Nahant, and Gloucester. It is doubtful, however, whether these records can be accepted, for when the name "sea bass" is used along the northern New England coast it usually proves that either striped bass, white perch (p. 257), tautog (p. 286), or even rosefish (p. 304) are the species actually meant.[23] No sooner do we round Cape Cod to the west, however, than we find the sea bass one of the important ground fish, but it is generally reported as steadily decreasing on the southern shores of New England, and this is borne out by statistics of the catch. On the rare occasions when this fish strays past the elbow of Cape Cod it is apt to be found near land, on rocky bottom, or around ledges, in water less than 10 to 15 fathoms deep, where it spends much of its time hidden in crevices among the stones.

Food.—The sea bass is a bottom feeder, subsisting chiefly on crabs, lobsters, shrimp, and various mollusks, and also eating small fish (e. g., launce and menhaden) and squid on occasion.

Habits.—Judging from its season at Woods Hole, where it is to be caught from May to October (most abundantly in July, August, and September), sea bass are to be expected in the Gulf of Maine in summer only, if at all. There is no reason to suppose that they ever succeed in reproducing or in establishing even a temporary foothold in the Gulf, even if the rare immigrants should spawn there. The height of its spawning season falls in June along southern New England, and it produces buoyant eggs.[24]

Commercial importance.—Too rare to be of any importance in the Gulf, the sea bass is a very valuable food and game fish in more southern waters.

THE CATALUFAS. FAMILY PRIACANTHIDÆ

100. **Big-eye** (*Pseudopriacanthus altus* Gill)

Jordan and Evermann, 1896–1900, p. 1239.

Description.—The most striking characters of this fish are its very large eyes and brilliant red color. Apart from these it is distinguishable from the sea-bass tribe by the fact that the whole head, as well as the body, is clothed with rough scales and that the anal fin is longer than the soft-rayed portion of the dorsal. Its compressed body, unusually stout dorsal spines, enormous ventral fins, and small pectorals, are ready field marks to separate it from the rosefish, the only Gulf of Maine species that rivals its brilliant red color. The big-eye is ovate in outline, very thin, with rounded dorsal profile, large head, notably oblique mouth, and enormous eye. The spiny (10 spines) and soft (11 rays) portions of the dorsal fin

[23] 3,000 odd pounds of "sea bass" reported from Manchester, Mass., in 1911, were certainly *not* this fish.

[24] The early development of the sea bass has been described by Wilson (Bulletin, U. S. Fish Commission, Vol. IX, 1889 (1891), p. 209).

are continuous and extend back from the nape nearly to the base of the caudal. The anal (3 stout spines and 9 to 10 rays) originates under the eighth or ninth dorsal spine and is of the same form as the soft portion of the dorsal. The caudal is square-cornered and slightly convex. The ventrals, which originate slightly in front of the pectorals, are much larger than the latter, round tipped, and each commences with a stiff spine.

Color.—Described as bright red or crimson in life. All its fins except the pectorals have black tips, and the iris glows like molten gold.

Size.—The largest specimen on record was 11 inches long.

General range.—Carribean Sea, West Indies, and Gulf of Mexico in rather deep water, straying northward to the Woods Hole region and very rarely rounding Cape Cod.

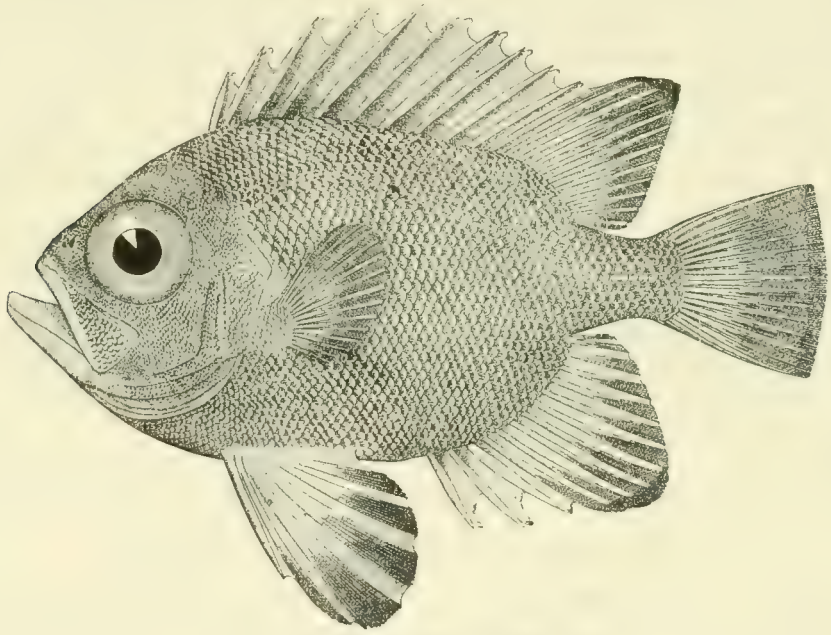

FIG. 124.—Big-eye (*Pseudopriacanthus altus*)

Occurrence in the Gulf of Maine.—A big-eye found alive on Marblehead Beach, September 3, 1859, still remains the only Gulf of Maine record for this southern species, but since it appears quite commonly at Woods Hole during some summers it may enter the Gulf more often than this suggests but be confused there with young rosefish.

THE SEA BREAMS OR PORGIES. FAMILY SPARIDÆ

In this family the structure of the fins is essentially the same as in the sea basses—both spiny and soft portions of the dorsal are well developed and the ventrals are thoracic in position and situated below the pectorals. There are important anatomic differences, however, most obvious of which are that the edge of the gill cover does not end with a sharp spine but is rounded or at most bluntly

angular, and that the maxillary bone (the bone forming the margin of the upper jaw) is sheathed and hidden by the preorbital bone when the mouth is closed. Long, pointed pectoral fins are likewise characteristic of the family, while the spiny and soft portions of the dorsal fin are continuous and the anal fin is about as long as the soft part of the dorsal.

KEY TO THE GULF OF MAINE PORGIES

1. Outline of caudal fin deeply lunate, with sharp corners.....Scup, p. 263
   Outline of caudal fin only slightly concave, with round corners.....Sheepshead, p. 268

101. Scup (*Stenotomus chrysops* Linnæus)

PORGY

Jordan and Evermann, 1896–1900, p. 1346.

Description.—Although the scup is not marked by any one outstanding character it is easily recognizable by the fact that the spiny portion of its dorsal fin is longer and higher than the soft-rayed portion, which, with its deeply lunate caudal fin, separates it from all other Gulf of Maine fishes of similarly deep and compressed body form. The body of the scup is nearly one-half as deep as long and very thin, recalling a butterfish (p. 245), but the dorsal profile of its rather short head is slightly concave and not convex as in the latter. The mouth is small, the eye situated high up on the head, and the margin of the gill cover is rounded. There is one long dorsal fin originating over the pectoral and preceded by a procumbent forward-pointing spine, spinous (25 spines) and soft (12 rays) parts being continuous. As a whole the fin is moderately high, its first spine much shorter than the others, and its rear corner rounded. The anal (3 spines and 11 rays) is about as long as the soft part of the dorsal (under which it stands), almost even in height from front to rear, but with the first spine shorter than the others. Both anal and dorsal fins are depressible in conspicuous grooves. The caudal is deeply concave with sharp corners, and the upper horn is noticeably longer than the lower. The pectorals are very long (reaching to the soft part of the dorsal), sharp pointed, and with slightly falcate lower margins. The ventrals, situated below the pectorals, are of moderate size. The scales are rather large.

Color.—Brown above, more or less tinged with reddish or pinkish, paling on the sides (which are silvery) to a silvery belly. W. C. Schroeder contributes the following description of the colors of about 100 scup, 6 to 10 inches long, taken in New Jersey pound nets in June, 1923:

> Dull silvery and iridescent; somewhat darker above than below; sides and back with 12 to 15 indistinct longitudinal stripes flecked with light blue; a light-blue streak following the base of the dorsal fin; head silvery, marked with irregular dusky blotches; belly white. Dorsal, caudal, and anal fins dusky and flecked with blue; pectoral fin of a brownish tinge; ventrals white and bluish, and very slightly dusky; iris silvery; pupil black.

Size.—The scup is said to reach a length of 18 inches and a weight of 3 to 4 pounds, but adults usually run only about 11 to 12 inches in length and 1½ to 2 pounds in weight.

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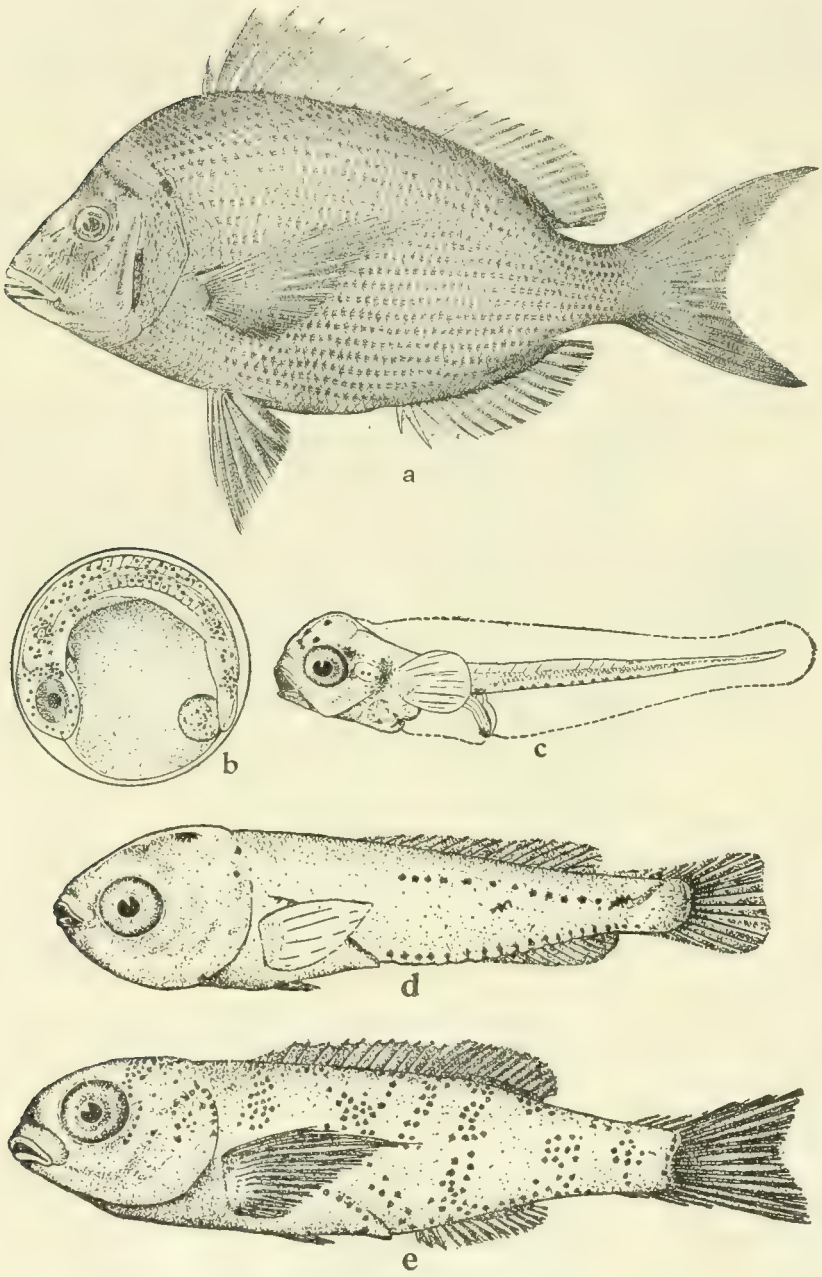

FIG. 125.—Scup (*Stenotomus chrysops*)

a, Adult. *b*, Egg. *c*, Larva, 3 days old, 2.8 millimeters. *d*, Fry, 10.5 millimeters. *e*, Fry, 25 millimeters.

General range.—East coast of the United States, common from South Carolina to Cape Cod; casual in the Gulf of Maine as far as Eastport.

Occurrence in the Gulf of Maine.—Although the scup is one of the most familiar shore fish right up to the elbow of Cape Cod, with the southern shore of Massachusetts and its off-lying islands yielding annual catches of 1,000,000 to 2,000,000 pounds in good years, very few find their way past Monomoy into the colder waters of the Gulf of Maine. The first definite mention of scup caught north of Cape Cod is Storer's statement that one was taken at Nahant in 1835, and another in 1836, but that it was never seen there before. Possibly, however, these and one picked up dead at Cohasset in 1833 [25] were the survivors of a smack load that had been liberated in Boston Harbor some years earlier (1831 or 1832). A similar "plant" was made in Plymouth Bay in 1834 or 1835, but there is no reason to suppose that these planted fish established themselves or that their introduction has in any way influenced the numbers of scup caught subsequently in the Gulf.

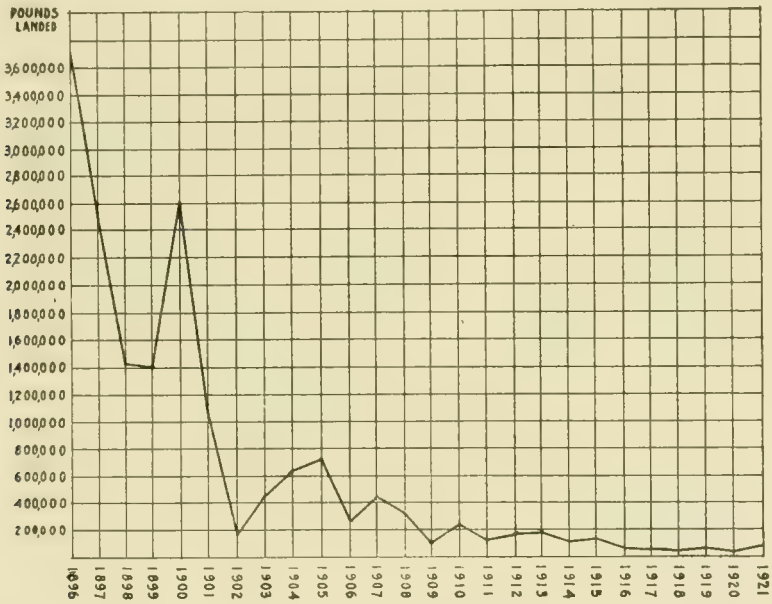

FIG. 126.—Annual catch of scup (pounds) in pound nets and traps in Massachusetts, from statistics published by the State commissioners of fisheries and game

When the practice of setting mackerel nets outside Provincetown Harbor was first adopted (about 1842) a few scup were taken in them from year to year, and it seems that a few stragglers appear in our waters during most summers, for odd fish were yearly caught in Cape Cod Bay and between Boston and Cape Ann during the period 1860 to 1867, and a number were taken in a weir on Milk Island near Glouscester in 1878. We find still larger catches reported from Manchester, Mass., in 1885, 1886, and 1887 (507, 1,243, and 1,755 pounds, respectively), and from Gloucester in 1888 (1,767 pounds); none at all, however, in 1889. Scup were reported in small numbers in one part of Massachusetts Bay or another nearly every summer from 1891 until 1904, and occasionally since then.

[25] The Fisheries and Fishery Industries of the United States, Section I, 1884, p. 387. Washington.

The returns of the pound-net fishery, published by the State of Massachusetts, list very much larger annual catches for the strip of coast between Boston and Cape Ann—chiefly at Manchester—in 1905, 1908, 1909, and 1910 (1,600 to 8,000 pounds); but inasmuch as a canvass of the Massachusetts fisheries made by the United States Bureau of Fisheries brought *no* reports of scup caught along this part of the shore line in the first of these years, while local inquiry has equally failed to elicit rumors of any unusual incursions of scup at any time since then, some other fish was probably responsible.[26]

Although scup are seldom or never plentiful enough to be of any importance, either commercially or to the angler, in Massachusetts Bay, the evidence just summarized shows that they are not only more constantly present there than are other southern fishes (for instance squeteague or bluefish), but that they do not show the wide fluctuations in abundance from year to year that characterize the latter, for it seems that the bay supports a few scup every summer though never many. The tremendous shrinkage that took place in the stock of scup off southern Massachusetts between 1896 (prior to which the annual catch had usually been from 1 to 3 million pounds) and 1905, since when it has seldom reached one-tenth of that amount, was not accompanied by a disappearance from Massachusetts Bay, as might have been expected if the local stock depended on drafts from the south for its maintenance. Thus scup do not fall in the same category as bluefish, weakfish, or menhaden, which come in abundance only when they are plentiful over the northern parts of their range as a whole, and otherwise rarely or not at all. They are regular visitors as far north as Cape Ann, though uncommon north of Cape Cod. The fact that scup are about as likely to appear in one part of Massachusetts Bay as another, as illustrated by the following table, supports this view.

Catch of scup in pound nets and weirs on the coast of northern Massachusetts, from Cape Cod to Cape Ann,[1] from 1891 to 1900, in pounds

Town	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900
Eastham			1							
Provincetown	157	21	41	111	380	101	2	17		
Truro	51	8	19	29		144	2			11
Wellfleet						[2] 632	5			
Sandwich	56	7	9							
Sagamore					266	54	139			
Revere					230					
Nahant					179	70	75	43	15	
Beverly			4							
Manchester		495				91				
Magnolia	3	19								
Gloucester	3		1		[3]		38	3	40	50

[1] We omit catches for Barnstable, Dennis, and Yarmouth because these *may* include fish from the southern as well as from the Massachusetts Bay shore of Massachusetts.

[2] From gill and sweep nets.

[3] Although no scup are listed from Gloucester for 1895, a few were reported there both in that and in the previous summer.

Cape Ann bounds the regular range of the scup. North of this point it has been reported twice only [27]—at Eastport and about Casco Bay. On the latter occasion (1896)—a year of plenty not only in Massachusetts Bay but to the

[26] Probably butterfish, which are not mentioned in these returns although undoubtedly caught in abundance in the traps in question.

[27] Knight (1867) reported "porgies" in the Bay of Fundy on hearsay, but Gulf of Maine fishermen would be more likely to apply that name to the menhaden than to scup.

south generally—they appeared in such numbers that odd specimens were taken daily in the Small Point traps during the first half of July, just such a sporadic visit as may be expected of a southern stray, and one so unusual that we have not heard of a scup caught anywhere along the coast of Maine since then.

The scup is strictly a summer fish in New England. Near Woods Hole they appear about the first of May, and most of them depart about mid-October, though some few linger through November and an occasional fish into December. Probably scup arrive somewhat later and depart earlier from Massachusetts Bay, but data are lacking on this point.

We have had very little first-hand experience with the scup. It is said that the first fish to arrive in spring are the large adults, with the immature fish following them later. During their summer stay they live in moderate depths. Large fish are seldom caught in shallower water than 2 or 3 fathoms, or deeper than 15 to 20 fathoms. Occasionally, however, they have been known to school on the surface, and young fry come close in to the land in but a few feet of water. At this season the scup is purely a coastwise fish. A line drawn 4 or 5 miles out from the outer headlands probably would inclose the entire stock. It is unknown on Georges Bank.

Habits and food.—Scup usually congregate in schools and prefer smooth to rocky bottom, which results in a distribution so local that one trap at Manchester took small numbers of scup in 1885, 1886, and 1887, while another close by did not yield as much as one fish. Scup are bottom feeders in the main, seldom rising far above the ground, the adults preying on crustaceans (particularly amphipods) as well as on annelids, hydroids, sand-dollars, young squid, and in fact on whatever invertebrates the particular bottom over which they live affords. They also eat fish fry to some extent, such free-floating forms as crustacean and molluscan larvæ, appendicularians, and copepods. The young feed chiefly on the latter and on other small Crustacea. Adult scup, like most other fish, cease feeding during spawning time, for which reason few are caught then, but throughout the rest of the summer they bite very greedily on clams, bits of crab, bloodworms (Nereis), etc., as do the immature fish throughout their stay. Undoubtedly it is the autumnal chilling of the coastal water that drives the scup away, for they are so sensitive to low temperatures that they have been known to perish in great numbers—both large fish and small—in sudden cold spells. While their winter home is unknown, it is more likely that they simply move out to sea to pass the cold season on bottom in deep water than that they journey far southward, the strongest evidence of this being their nearly simultaneous appearance all along the southern coast of New England in spring, and the fact that small scup, probably devoured while on their way offshore, have been found in autumn in cod stomachs on Nantucket Shoals, where they are unknown in summer. This autumn migration probably leads the scup of southern New England to the continental slope, and no doubt the few that summer in Massachusetts Bay leave the Gulf of Maine altogether for the cold season, journeying out past Cape Cod to the same goal, for since few are seen anywhere in spring until the coastwise waters have warmed to about 50°, it is not likely they could survive the considerably lower temperature (about 41° to 43°) of even the deepest trough of the Gulf of Maine.

Breeding habits.—Along southern New England scup spawn from May to August—chiefly in June. Probably spawning both commences and continues later, in the case of the few fish that manage to summer in Massachusetts Bay, and it may be assumed that the fish spawn wherever they summer.

The eggs are buoyant, transparent, spherical, rather small (about 0.9 mm. in diameter), and with one oil globule. Incubation occupies only about 40 hours at 72°—probably two to three days in the June temperatures of Massachusetts Bay—and judging from the season of spawning at Woods Hole, it is not likely that development can proceed normally in water colder than about 50°. At hatching the larvæ are about 2 mm. long, the yolk is fully resorbed within three days when the larva is about 2.8 mm. long, and there is then a characteristic row of black pigment spots along the ventral margin of the trunk. Fry of about 10 mm. show the dorsal and ventral fin rays. At 25 mm. the pectorals have assumed their pointed outline and the caudal fin is slightly forked, but the ventrals are still so small and the body so slender that the little fish hardly suggest their parentage until somewhat larger.[28]

Rate of growth.—In southern New England fry of 2 to 3 inches, evidently the product of that season's spawning, have been taken in abundance as early as September. In October they are 2½ to 3¼ inches long, and may be as long as 4 inches at Woods Hole in November. Apparently young scup grow very little during the winter, for in spring the large mature fish are soon followed by small ones of 4 to 6 inches, probably the crop of the preceding season. It has been generally assumed, following Baird (1873, p. 228), that the large fish of 12 to 14 inches, weighing from 1½ to 2½ pounds, are 3 to 5 years old, but no growth studies based on the scales or other exact data have been attempted for this fish.

102. **Sheepshead** (*Archosargus probatocephalus* Walbaum)

Jordan and Evermann, 1896–1900, p. 1361.

Description.—The sheepshead so closely resembles the scup in its general organization that the family relations between the two are obvious. Like the scup it is deep bodied and much compressed, with similar profile. There is one long dorsal fin, scuplike in outline, of which the anterior two-thirds is spiny (12 spines) and the posterior one-third is soft (10 to 12 rays). The anal fin (3 spines and 10 to 11 rays) is about as long as the soft portion of the dorsal, under which it stands, and both dorsal and anal can be depressed in deep grooves. The pectorals are long and pointed, the ventrals are situated slightly behind the latter, the scales are large, and the eyes are located high on the sides of the head, in all of which the sheepshead agrees with the scup. It is readily recognized, however, by the fact that its caudal fin is not so deeply emarginate as that of the scup, and has rounded and equal corners instead of pointed and unequal ones, while its dorsal spines are alternately stout and slender, its second anal spine much stouter than that of the scup, the dorsal profile of its head is steeper, its nose is blunter, and its teeth are much broader. Furthermore, the body of the sheepshead is noticeably thicker and the back is

[28] Kuntz and Radcliffe (1918, p. 106) describe the early development of the scup.

rounded. Instead of being plain colored like the scup, the sides of the sheepshead show seven broad, dark brown crossbars on a gray ground.

Size.—The sheepshead grows to a length of 30 inches and a weight of 20 pounds.

General range.—Atlantic and Gulf of Mexico coasts of the United States from Texas to Cape Cod. Casual in the Bay of Fundy.

Occurrence in the Gulf of Maine.—The sheepshead was formerly abundant as far north as New York and not uncommon about Woods Hole. Though still a common fish in the south, it has been decidely rare east of New York for many years past. The only record of it east of Cape Cod is Cox's (1896, p. 71) statement that it is occasional in St. John Harbor, New Brunswick; but no actual specimens are mentioned, and as it is not known ever to have strayed to Massachusetts Bay (a far more likely goal for any southern coast fish than the Bay of Fundy), its claim to mention here is slender.

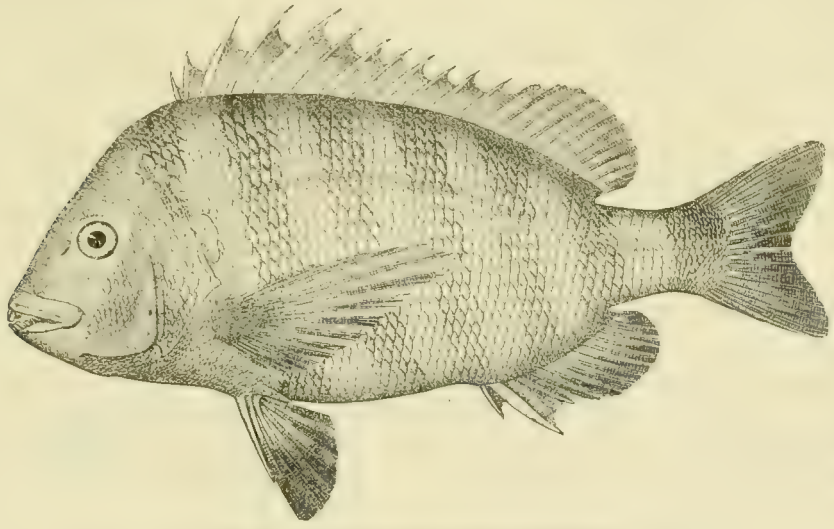

FIG. 127.—Sheepshead (*Archosargus probatocephalus*)

THE CROAKERS OR WEAKFISHES. FAMILY SCIÆNIDÆ

The croakers have both spiny and soft portions of the dorsal fin well developed (either separate or as one continuous fin) and their ventrals are thoracic in position. They are readily separable from the sea basses (p. 251), the sea breams (p. 262), and the cunners (p. 280) by the fact that the anal fin is much shorter than the soft portion of the dorsal; from the rockfishes and sculpins by the smooth head; and from all the mackerels and the pompano tribe by their stout caudal peduncles and rounded or only slightly concave caudal fins.

KEY TO GULF OF MAINE CROAKERS AND WEAKFISHES

1. There is no barbel on the chin ..... Weakfish, p. 270
   Chin with one or more barbels 2
2. Several chin barbels; the spiny and soft-rayed portions of the dorsal fin are connected ..... Drum, p. 279
   Only one chin barbel. The spiny and soft-rayed portions of the dorsal are two separate fins ..... Kingfish, p. 277

103. **Weakfish** (*Cynoscion regalis* Bloch and Schneider)

SQUETEAGUE; SEA TROUT; TROUT; GRAY TROUT

Jordan and Evermann, 1896–1900, p. 1407

Description.—The relative sizes and shapes of the fins of the weakfish and its color are such ready field marks that it is one of our most easily named fishes. With regard to other Gulf of Maine fishes with separate spiny and soft-rayed dorsal fins, it is distinguishable from the mullet by the considerable length of its dorsal as well as by many other characters. Its only slightly emarginate tail distinguishes it from any mackerel or pompano. This same character, combined with a short anal fin and a first dorsal fin higher than the second gives it an appearance quite different from a bluefish, while the fact that its second dorsal is much longer than the first and its body slender obviates all danger of confusing it with striped bass or white perch. The shape of the dorsal and caudal fins and of the head make it distinguishable at a glance from the kingfish (p. 277), the absence of barbels on the chin separates it from a drum, while it has nothing in common with such bizarre fish as the John Dory (p. 291), triggerfish (p. 293), or the sculpin tribe (p. 314).

The weakfish is a slim, shapely fish, about four and one-fourth times as long as deep (counting the caudal), only slightly compressed, with rather stout caudal peduncle, long head, moderately pointed snout, and large mouth. Its upper jaw is armed with two large canine teeth and its lower jaw projects beyond the upper. The first dorsal (9 to 10 spines), originating slightly behind the pectoral, is triangular: the second, originating close behind it, is more than twice as long (26 to 29 rays) and roughly rectangular. The caudal fin is moderately broad and but slightly concave in outline. The anal fin (1 or 2 very slender spines and 11 to 13 rays) is less than half as long as the second dorsal, under the rear of which it stands. The ventrals are below the pectorals, which they resemble in their moderate size and pointed outline.

Color.[29]—Dull brownish or olive green above with the back and sides variously burnished with purple, lavender, green, blue, golden, or coppery, and marked with a large number of small black, dark green, or bronze spots. These spots are vaguely outlined and run together more or less, especially on the back, thus forming irregular lines running downward and forward. They are most numerous above the lateral line. There are no spots on the lower sides or belly. The lower surface, forward to the tip of the jaw, is white—either chalky or silvery. The dorsal fins are dusky, usually more or less tinged with yellow, the caudal is olive or dusky with its lower edge yellowish at the base, the ventrals and anal are yellow, and the pectorals are olive outside and usually yellow inside.

Size.—It is said that weakfish as heavy as 30 pounds have been taken, but the largest of which we can find authentic record in recent years was an 18-pounder. A fish heavier than 12 pounds or longer than 3 feet is a rarity. Off southern Massachusetts the largest fish run 6 to 10 pounds in weight, and most of those taken there

[29] W. C. Schroeder, of the Bureau of Fisheries, has supplied notes on the color of a freshly caught specimen 17 inches long.

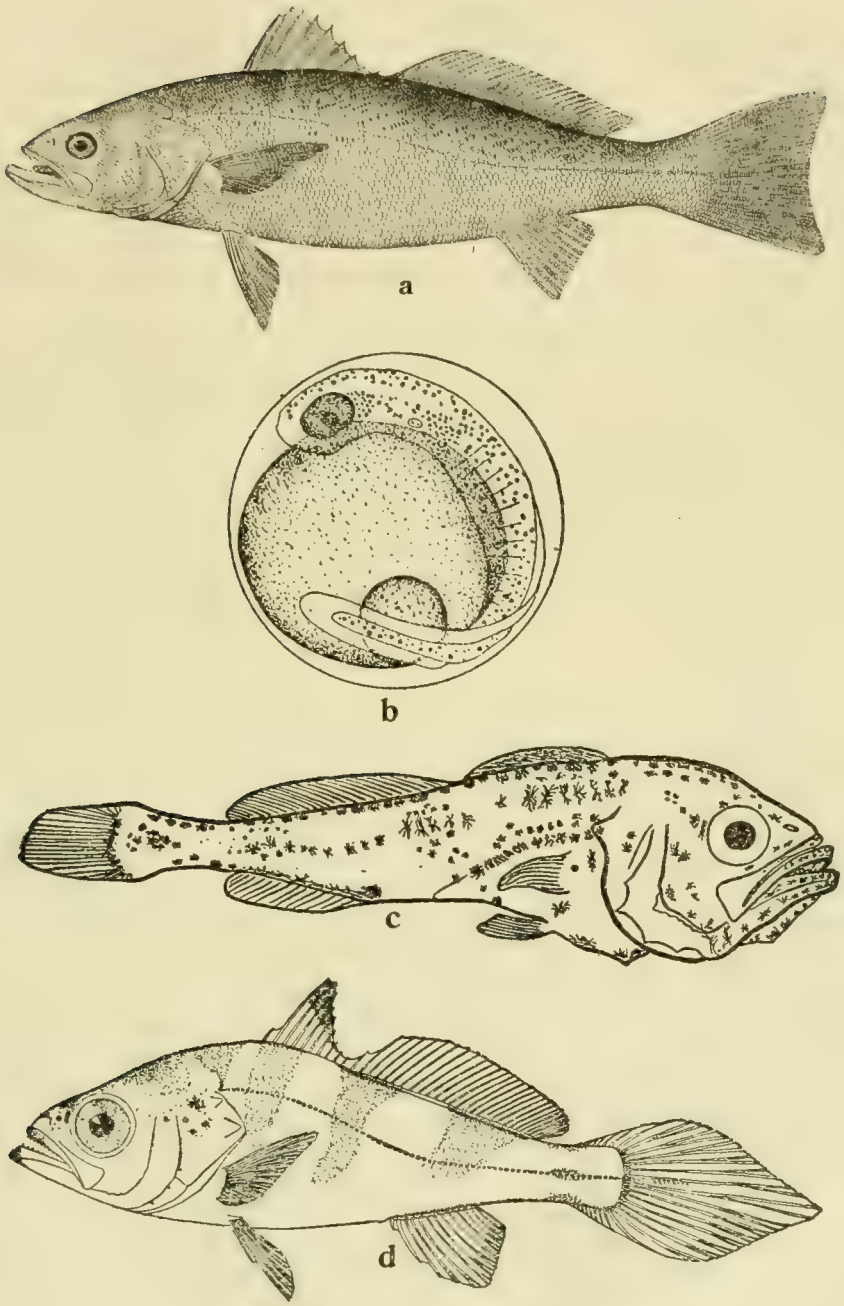

FIG. 128.—Weakfish (*Cynoscion regalis*)

a, Adult. *b*, Egg. *c*, Larva, 12.4 millimeters. *d*, Fry, 32 millimeters.

weigh from 1 to 6 pounds and are 1½ to 2½ feet long. An average of 5 pounds has been reported for Massachusetts Bay, but this is probably excessive. The average proportion between length and weight is about as follows:

Length in inches	Weight in pounds
12 to 14	⅔ to 1
14 to 16	1⅓ to 2
18 to 20	1⅔ to 2½
22 to 23½	3½ to 4⅓
25½ to 27½	5 to 6

General range.—Eastern coast of the United States from Massachusetts Bay to the Gulf of Mexico.

Occurrence in the Gulf of Maine.—The chief center of abundance of the weakfish is the coast of the middle Atlantic States from New York southward. It occurs regularly to Cape Cod. The stock of weakfish fluctuates widely on the southern New England coast, and it is only during periods of great abundance there that it appears in any numbers in Massachusetts Bay, which may be set as the extreme northern limit for its appearance in any numbers.[30] In the years when it has passed Cape Cod in appreciable numbers it has always been far more plentiful along the inner side of the cape and in Cape Cod Bay than north of Boston, as appears from the following statement of catches for 1906:

	Pounds
Cape Cod Bay:	
Provincetown	115, 789
Truro	202, 050
Brewster	137, 659
Sandwich	6, 221
North Shore, Massachusetts Bay:	
Nahant	369
Manchester	410

Twenty thousand pounds were also returned from Gloucester, but we have reason to believe that although landed there the fish were caught in Cape Cod Bay, and though traps have been operated at Rockport and at Newburyport they have taken no weakfish.

Fortunately the statistics of the pound-net fishery cover the inception, climax, and eclipse of the only invasion of Massachusetts Bay by weakfish that has occurred within the past century.[31] Apparently weakfish were plentiful off southern New England during the last part of the eighteenth century, and to judge from fishermen's reports weakfish were well known in Massachusetts Bay at that time; but they vanished so completely sometime prior to 1800 that when a single stray specimen was taken at Provincetown in June, 1838, it was sent to Boston for identification. This disappearance was evidently but part of a general phenomenon of the same sort covering the whole northern part of the range of the species, for it disappeared similarly from the Nantucket-Marthas Vineyard region sometime

[30] It is credited indefinitely to "Maine" by Holmes (1862); Goode, et al. (1884, p. 362), state that scattering individuals have been caught as far as the Bay of Fundy; and Halkett (1913) mentions one as probably caught off Nova Scotia.

[31] There are intimations in the writings of the early historians of New England of similar disappearances and returns of the weakfish (Goode, et al., 1884, p. 363).

between 1800 and 1837. By 1867, however, they had reappeared off southern Massachusetts, and by 1870 they were once more abundant there, but weakfish were not reported again north of Cape Cod until 1884, when one or two were taken off Truro and Provincetown. From then until 1895 a few were returned yearly from Truro, Provincetown, Plymouth, and even from as far north as Gloucester and Manchester, the annual catch ranging from an odd fish only (e. g., 1893 and 1894) to 700 or 800 pounds, at most, for the entire bay. The catch in the Gulf for the next few years was larger (4,892 pounds in 1896, [2] 1,006 pounds in 1897, 6,046 pounds in 1898, and 11,572 pounds in 1899), though the weakfish was still a comparatively unimportant fish, with the catches localized chiefly on the outer side of Cape Cod and in Cape Cod Bay, as might be expected of a stray from the south. In 1900, however, they appeared in such numbers in Massachusetts Bay that the catch jumped to upward of 130,000 pounds.[32] A few were taken even as far north as Gloucester and in Boston Harbor.

This marked the commencement of a period of local abundance entirely unexpected (nothing like it had been experienced since the settlement of the country), and which, with its equally sudden eclipse, is perhaps the most interesting event in the history of the fisheries of the Bay. Unfortunately definite statistics of the catches are not available for the crucial years, but in 1901 the fish was so plentiful in Cape Cod Bay as to be a drug on the market. In 1902 and 1903 the pound nets in Cape Cod Bay were often filled with schools of large weakfish, averaging about 5 pounds. So plentiful were they, indeed, during the latter summer that traps at North Truro alone reported 280,000 pounds. This abundance continued through 1904, by which time it seems to have been accepted as the normal condition and hence no longer worth comment. It culminated in that or the following summer, for weakfish were reported as less plentiful in 1906, but nevertheless the Massachusetts Bay traps (excluding Barnstable, Yarmouth, and Dennis) reported almost half a million pounds of weakfish for that year, and this probably was not more than half or two-thirds of the actual total, for the returns were incomplete. This was the last big year, for the Massachusetts Bay catch of 1907 was only about one-third that of 1906, a falling off that was the beginning of the end, only 8,249 pounds being reported in 1908, 369 pounds in 1909, and 17 pounds in 1910. We do not know of a single weakfish caught in Massachusetts Bay since 1916,[33,34] unless a few odd fish reported at Barnstable in 1921 were taken on the Bay shore and not the Vineyard Sound or Buzzards Bay shore.

It is impossible to account for the unexpected rise and the even more sudden fall of weakfish north of Cape Cod, because the opportunity is gone to gather such data on the size and age of the fish, their movements, the precise seasons of the catch, and the physical state of the water as might clear the question. It was no local event, however, but reflected a corresponding fluctuation in the whole stock of weakfish existing north of New York, for the catch of weakfish along the southern

[32] Omitting the towns of Yarmouth, Dennis, and Barnstable, where traps have been operated on the Vineyard Sound as well as on the Massachusetts Bay side.

[33,34] No pertinent statistics are available for the years 1912 to 1915.

coast of New England was more than eight times as great in 1904 (upward of 7,000,000 pounds) as in 1889 (about 830,000 pounds), but thereafter declined so markedly that in 1908 complaint of the scarcity of weakfish was made by both the commercial fishermen and the anglers of Rhode Island and southern Massachusetts. Less than 400,000 pounds were taken in all New England in 1919, and by 1920 and 1921 the weakfish had so nearly vanished from the southern as well as the Massachusetts Bay shores of Massachusetts that the reported catches for the State were but 785 and 691 pounds, respectively. Whether the next few years will see the weakfish entirely disappear east of Narragansett Bay for a period of years, as seems to have happened in the late seventeen hundreds, or whether we may now look for an increase, the future alone can tell. Perhaps we should emphasize in passing that throughout the period under discussion about the same number of pound nets and traps have been operated from year to year at about the same general localities, so that fluctuations in the catch do actually reflect similar fluctuations in the stock of fish.

It has often been suggested that weakfish are plentiful when bluefish are scarce, and vice versa, and the argument has been advanced that the latter not only devour fry of the weakfish but its food as well, and hence not only destroy many but drive others away, but no convincing evidence that the fluctuations of these two species of fish are in any way mutually dependent has been brought forward.

Habits.—Although there are no weakfish in the Gulf of Maine to-day, they were so plentiful in its southwestern waters for a time—and may at any time reappear there in abundance—that their habits deserve more attention than the fish's present status would call for. In the southern part of its range (e. g., along the Carolinas) it is a resident species, as sundry authors have remarked. North of Chesapeake Bay, however, it is strictly seasonal, appearing in spring, spending the summer on the coast, and departing once more in autumn. At Woods Hole it is caught from May (some years as early as April, others not until June) until the middle of October. Probably it is not to be expected north of Cape Cod before June, and although no records have been kept of its days of arrival and departure there, it is not likely that it lingers in the Gulf later than September, for adult weakfish disappear from the middle Atlantic coast in October.

During their stay on the coast weakfish keep close inshore, being unknown on Nantucket Shoals, Georges, or Browns Banks. They are usually found along open sandy shores in the larger bays, estuaries, and sheltered waters generally, even running up into river mouths. Although no precise information is available as to the presence of weakfish in relation to the temperature of the water, it is well known that they are extremely sensitive to cold.

Weakfish move in schools that are usually small but sometimes consist of many thousands.[35] They have usually been described as swimming near the surface, this being the general rule off the southern New England coast, where great numbers were caught on hook and line within a few feet of the top of the water, and their

[35] A notable and oft-quoted instance was off Rockaway Beach, N. Y., July, 1881, when a school was sighted so large that three menhaden steamers seined some 200,000 pounds of weakfish averaging 1½ to 3 feet in length and 3 to 7 pounds in weight.

preference for shallow water is reflected in the large numbers caught in pound nets during the years when they visit the Gulf of Maine. Probably few descend deeper than 5 to 6 fathoms during the summer, but the precise level at which they live at any given locality is governed by their food; on open coasts they often feed on bottom in the surf. They are also bottom feeders in certain inclosed waters, e. g., parts of Delaware Bay.

As Welsh and Breder (1924, p. 158) point out, very little is known regarding the movements of the schools of weakfish during their annual stay on the coast, but it is probable that these depend largely upon the configuration of the coast line. In Delaware and Chesapeake Bays, for example, they describe the main bodies of fish as running far up on their first arrival, then returning seaward to the ocean in June, but reentering the bays in the later summer. However, it is doubtful whether this on and off shore migration, which is associated with spawning, occurs on such open coasts as those of Cape Cod Bay.

The winter home of the northern weakfish is still to be discovered, but it is now generally assumed that their autumnal migration takes place to avoid falling temperature, and that they either move offshore to pass the cold season on the continental edge, or southward.

Food.—Weakfish are carnivorous and voracious, feeding on a wide variety of animals, including crabs, amphipods, shrimps, and squid, but chiefly on smaller fish, such as menhaden, butterfish, herring, scup, anchovies, silversides, and mummichogs, of which they destroy vast quantities. The precise diet varies with the locality (that is, with what is most readily available), but menhaden is probably the most important single item, and adult weakfish usually depend on fish, though occasionally they have been found feeding exclusively on crustaceans, but we can not learn that shellfish have ever been found in weakfish stomachs. The young subsist chiefly on fish fry, shrimp, and on other small crustaceans, larval as well as adult, and the proportion of Crustacea in the diet averages much greater with small weakfish than with large.[36] Weakfish bite very greedily on various kinds of bait, especially on shedder crabs, clams, shrimp, and mummichogs.

Breeding habits.—Weakfish spawn from May to October on the middle Atlantic coast, with the chief production of eggs between mid-May and mid-June, probably June and July in Massachusetts Bay. The following account of the breeding and development of the weakfish is condensed from Welsh and Breder (1924, p. 150). The eggs have been taken in tow nets at various localities in temperatures ranging from 60° to 70°, in salinities of 28.01 to 30.9 per mille, and it is probable that weakfish spawn locally around the shores of Cape Cod Bay in years when the fish are plentiful there, as they do regularly about Woods Hole, the summer temperature of the surface being sufficiently high. Spawning is confined to the immediate vicinity of the coast, taking place chiefly in the larger estuaries or close to their mouths, usually at night. The eggs are buoyant, spherical, 0.74 to 1.1 mm. in diameter, usually with one, rarely with as many as four, oil globules that coalesce into one large one as development progresses. Incubation occupies 36 to 40 hours

[36] For diet lists of weakfish of various sizes and from many localities, see Welsh and Breder (1924, p. 159), and also Peck (Bulletin U. S. Fish Commission, Vol. XV, 1895 (1896), p. 352).

at a temperature of 68° to 70°; the newly hatched larvæ are 1.75 mm. long, growing to about 2.2 mm. in 24 hours, by which time most of the yolk has been absorbed.

The rays of the ventral fins are visible in larvæ of 6.5 mm. At 12.5 mm. the larval finfold has disappeared, the fins are fully formed, and the sides are barred with four dusky bands. From this stage onward the family relationship of the young fry is made evident by the short anal and long second dorsal fins, and at 30 mm. they have attained most of the structural characters of the adult; but until they are 6 to 8 inches long the young weakfish are much deeper and more compressed than their parents, their heads and eyes are relatively larger, and their caudal fins are obtusely pointed, with the center rays much the longest, instead of concave. The smaller fry (of 1½ to 3 inches) are marked with four dark, saddle-shaped patches extending downward on the sides to slightly below the lateral line, which are not obliterated until the length of about 4½ inches is attained. As the young fish grow, other bands of pigment are interpolated below the lateral line, the adult coloration not being fully developed until the length of 7 to 8 inches is reached.[37]

Rate of growth.—Weakfish fry grow at such a rapid rate during the first summer that, according to Welsh and Breder, fish hatched June 1 will average 1¼ inches in length on July 1 (1 month), 3⅛ inches on August 1 (2 months), 5⅛ inches on September 1 (3 months), 6¾ inches on October 1 (4 months), and 7⅛ inches on November 1 (5 months). Growth practically ceases during the first winter, and the smallest fish seen in spring (no doubt yearlings) are 8 to 10 inches long. Thereafter the rate of annual growth is much slower, but the variation in the length attained by the fry during their first summer and autumn, consequent on the protracted spawning season, combined with the fact that scale studies of this species have proved puzzling, makes it difficult to group the older age classes by size.

Welsh and Breder estimated the ages of 74 fish of different sizes from Cape May, N. J., as 8½ inches at 1 year, 11 inches at 2 years, 13 inches at 3 years, and 14⅛ inches at 4 years of age, and Taylor estimated the length of 6-year-olds as about 22 inches, of 7-year-old fish as about 24 inches, but a 9-year-old example (age judged from the scales) examined by Welsh and Breder was only 19¼ inches long. Females usually mature at 3 to 4 years of age, males at 2 to 3 years, and both sexes spawn annually thereafter. Welsh and Breder found most of the spawning fish at Cape May to be 4 to 6 years old.

Commercial importance.—At the present time the weakfish is of no commercial importance in the Gulf of Maine, but during its brief periods of plenty there it is a very valuable addition to the shore fisheries of Massachusetts Bay. Along more southern coasts, where it occurs regularly, it is one of the most important of food fishes [38] and a favorite game fish.

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[37] Tracy (Thirty-eighth Annual Report, Commissioners of Inland Fisheries of Rhode Island, January Session, 1908, pp. 85–91), Eigenmann (Bulletin, U. S. Fish Commission, Vol. XXI, 1901 (1902), p. 45), and Welsh and Breder (1924, p. 154) describe the older larvæ and fry.

[38] The annual catch of the three species of squeteague combined (*Cynoscion regalis*, *C. nebulosus*, and *C. notus*), for the Atlantic and Gulf coasts, is upward of 40 million pounds ,of which the weakfish probably contributes more than one-half.

104. **Kingfish** (*Menticirrhus saxatilis* Bloch and Schneider)

KING WHITING; MINKFISH; WHITING; SEA MULLET

Jordan and Evermann, 1896–1900, p. 1475.

Description.—The kingfish recalls the weakfish in the general arrangement and the relative sizes of its fins, the second dorsal being much longer than the first or than the anal, but its first dorsal (10 spines) is relatively much higher and more pointed than that of the weakfish, with its third spine not only much elongate but filamentous at the tip (a noticeable character), while the rather blunt nose with snout overhanging the mouth give the kingfish a very characteristic cast of countenance (fig. 129). Its upper jaw, furthermore, projects beyond the lower, whereas the reverse is the case in the squeteague. Its chin bears a barbel, which the latter lacks, its lips are fleshy, and it has no canine teeth. Its tail, too, is of very characteristic outline, with its lower half rounded and the upper emarginate, suggesting,

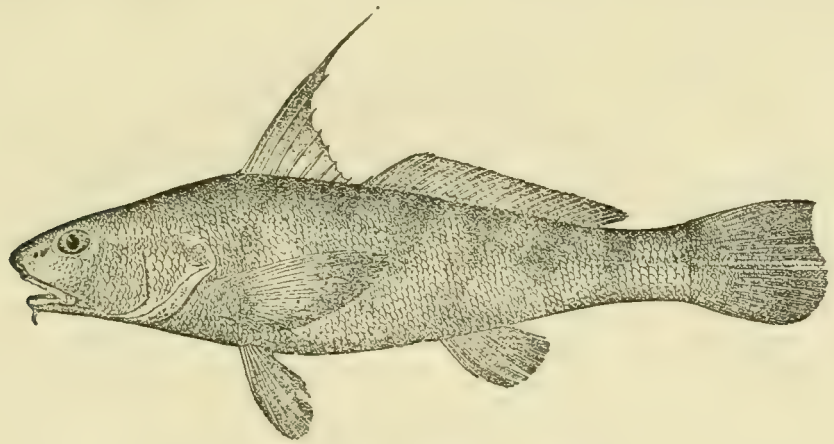

FIG. 129.—Kingfish (*Menticirrhus saxatilis*)

though not exactly paralleling, the tail of the sea bass (p. 260). Though it is about as slender, proportionally, as a squeteague, the kingfish carries its weight farther forward (it is deepest below the first dorsal), and has a weak-tailed appearance remotely suggesting a hake (p. 446). We need merely note further that the filamentous spine of the first dorsal is longer in large fish than in small ones; that the second dorsal (one stout but short spine followed by 26 or 27 rays) is about one-third as long as the fish and tapers slightly from front to rear; that the anal (one long spine and 8 rays) stands under the middle of the second dorsal; and that the pectoral is pointed and relatively much longer than that of the squeteague.

Color.—Leaden or dusky gray above—sometimes so dark as to be almost black—with silvery and metallic reflections; milky or yellowish-white below. The sides are marked irregularly with dark bars. Behind the spiny dorsal these run obliquely forward and downward, but the foremost one or two run in the opposite direction forming a V-shaped blotch or two dark Vs below the fin. The

pale belly is bounded by a dark longitudinal streak on either side. The fins are dusky or blackish, the first dorsal, anal, pectorals, and ventrals tipped with dirty white.

Size.—Kingfish grow to a maximum weight of about six pounds, but fish as large as this are rare, the general run being only 1 to 3 pounds. They average about 13¾ inches in length in their third winter.[39]

General range.—Gulf and Atlantic coasts of the United States; common northward to Cape Cod; casual to Casco Bay.

Occurrence in the Gulf of Maine.—This excellent food fish is only a stray from the south in the Gulf of Maine. So far as we can learn the only positive records of it within our limits from south to north are as follows: Monomoy and North Truro on Cape Cod in 1896 (collected by Dr. W. C. Kendall); one specimen taken at Provincetown, July, 1846; another there in November, 1847; and many small ones, apparently chilled by the cold, that appeared in that harbor in 1879; one taken at the entrance of Boston Harbor in a lobster pot some time before 1833; one at Lynn in 1840; one 8 inches long off Marblehead on October 15, 1872; one of 6½ inches at Danvers, October 28, 1874; others at Nahant (one record) and in Casco Bay. Thus it is evidently an unusual event for even an odd kingfish or for a small school of its fry to round the elbow of Cape Cod.[40]

Kingfish were once fairly common along the southern New England coast. In 1889, for example, about 4,000 pounds were returned for Massachusetts and almost 10,000 pounds for Rhode Island, but since that time they have so diminished that in 1919 the Massachusetts catch was only 72 pounds while none at all was reported from Rhode Island.

Food and habits.—Kingfish, like squeteague, are summer fish, appearing in May and vanishing in October. They are confined to the immediate vicinity of the coast during their stay, frequenting inclosed as well as open waters and even entering river mouths. They are unknown on the offshore banks. Kingfish run in schools, keep close to the ground, prefer hard or sandy bottom, and feed on various shrimps (perhaps their chief diet), crabs, and other crustaceans, small mollusks, worms, and on young fish. As they bite readily and fight well they are a favorite game fish for anglers with rod and reel.

Breeding habits.—Kingfish spawn in bays and sounds from June until August, but it is not likely that any larvæ that might be hatched in the Gulf of Maine from eggs laid by the occasional visitors would survive its low temperature. Welsh and Breder (1924, p. 190) describe the spawning and early development of this species.

The eggs are buoyant, 0.76 to 0.92 mm. in diameter, with one to several oil globules that coalesce as development proceeds. Incubation occupies about 46 hours at a temperature of 68°. Newly hatched larvæ are 2 to 2.5 mm. long. When hatched, the larvæ float inverted, but as the yolk shrinks they assume the normal position. By the fourth day the yolk is wholly absorbed and the mouth formed.

[39] Welsh and Breder, 1924, p. 194.

[40] Small amounts of "kingfish" appear in the pound-net returns published by the State of Massachusetts at various localities in Massachusetts Bay, but fishermen inform us that these are not the true kingfish but some large species of mackerel or bonito.

The larvæ are marked at first with three vertical bands of black and dull gold pigment cells—the first above the vent, the others posterior to it, dividing the caudal region into three nearly equal parts. There is a similar patch of black and gold on the anterior part of the dorsal finfold, but as development proceeds these markings become fainter and a row of black pigment cells appears along the ventral surface behind the vent. The later larval stages are not known, and the youngest fry so far taken (25 to 30 mm. long) show most of the structural characters of the adult, including the scales, and are readily recognizable as kingfish though they vary widely in color, ranging from the pattern of the adult to almost uniform blackish brown.[41] From an examination of the scales, confirmed by a large series of measurements, Welsh found that kingfish are 4 to 6 inches long by the first winter, average about 10 inches the second winter, and 13¾ the third. Many males ripen when two years old, but few females until three years old.

Commercial importance.—The kingfish is too rare in the Gulf to interest either commercial fishermen or anglers. It is, however, one of the best of table fish.

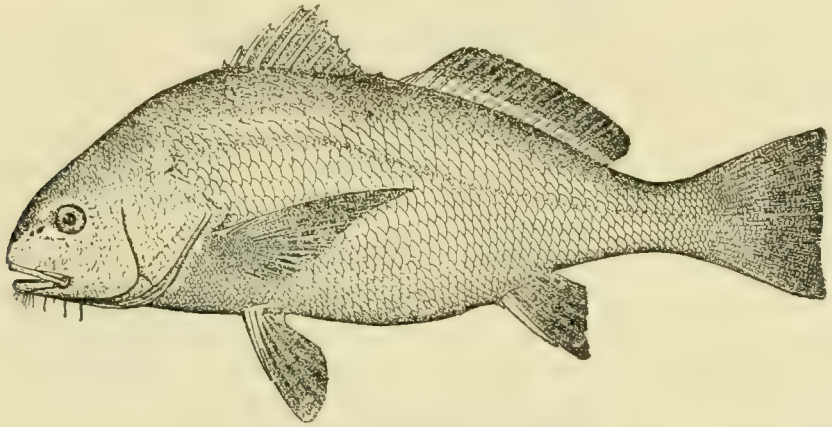

FIG. 130.—Black drum (*Pogonias cromis*)

105. **Black drum** [42] (*Pogonias cromis* Linnæus)

Jordan and Evermann, 1896–1900, p. 1482.

Description.—A short deep body (only three and one-third times as long as deep) with high-arched back but flat belly is characteristic of the drum. The profile of the face, too, is even more diagnostic, for the mouth is very low down, the eye high up, and the chin bears a number of barbels. The arrangement and sizes of the fins are essentially the same as in the weakfish, except that the spinous and soft dorsals are not entirely separate, while the latter is relatively shorter and the anal spine

[41] This account is from eggs artificially fertilized and hatched by Welsh.

[42] The channel bass, or red drum (*Sciænops ocellatus* Linn.), a southern Sciænid uncommon east or north of New York, is represented in the collection of the Boston Society of Natural History by a mounted specimen labeled "near Portland, Me.," but since this fish was probably purchased in the market it is more likely that it had been shipped from the south than that it was actually caught nearby. Should this species ever be taken in the Gulf of Maine, its relationship to the weakfish, kingfish, and drum would be apparent from the arrangement of its fins, especially from the shortness of the anal fin relative to the soft (second) dorsal. However, it is easily distinguished from the weakfish by the fact that its upper jaw extends beyond the lower, instead of vice versa, and from kingfish and drum by the lack of barbels on the chin, while the presence of a conspicuous black blotch (rarely two blotches) on each side at the base of the caudal fin affords a ready field mark for its identification.

much stouter. The jaw teeth are small and pointed, but the large, flat, pavement-like pharyngeal teeth with which the drum crushes its shellfish food help to separate it from its allies, the squeteague and kingfish. The first dorsal fin (10 spines) is triangular; the second (1 short spine and 21 rays) oblong; the caudal is square with moderately high caudal peduncle; the anal (2 spines —the first very short and the second very long and stout—and 5 or 6 rays) is less than half as long as the soft portion of the dorsal; and the pectorals are sharp pointed and relatively longer than those of the weakfish. The second anal spine is much stouter in young drums than in old ones. The eyes of the drum are comparatively small and its scales are large.

Color.—Described as grayish silvery. Young fish have 4 or 5 broad dark vertical bars that fade out with age. The fins are blackish. This drum occurs in two color phases—a grayish and a reddish.

Size.—Drums grow to a huge size. The largest we find positively recorded (caught in Florida) weighed 146 pounds, but adults average only about 20 pounds in weight.

General range. —Atlantic and Gulf coasts of America from Argentina to New England, common from New York southward and abundant from the Carolinas to the Rio Grande; casual as far north as Massachusetts Bay.

Occurrence in the Gulf of Maine.—Two or three specimens of this southern fish have been taken at Provincetown, and one in the Mystic River, which empties into Boston Harbor. It is only a stray from the south in the Gulf of Maine.

THE CUNNERS. FAMILY LABRIDÆ

In the cunner family there is a single long dorsal fin, its forward part spiny, its rear part soft rayed, with no evident demarkation between the two. The ventral fins are thoracic in position, situated under the pectorals, and the caudal peduncle is very broad. The structure of the dorsal fin is sufficient of itself to distinguish the cunners from all Gulf of Maine fishes except the scup, sea bass, rosefish, and tilefish. There is no danger of confusing a cunner or tautog with any of these, for their caudal peduncles, rounded tails and pectorals, and general form separate them at a glance from the flat-bodied, fork-tailed scup; their small mouths and the relative sizes of the fins are obvious distinctions between cunners and sea bass; their smooth cheeks and broad caudal fins separate them from the spiny-headed, narrow-tailed rosefish; and they do not in the least resemble the tilefish with its broad mouth, adipose "fin" on the nape, concave tail, and pointed pectorals.

KEY TO GULF OF MAINE CUNNERS

1. Gill covers scaly, snout somewhat pointed, dorsal profile of head rather flat__Cunner, p. 281
   Gill covers largely naked, snout blunt, dorsal profile of head high-arched__Tautog, p. 286

106. Cunner (*Tautogolabrus adspersus* Walbaum)

PERCH; SEA PERCH; BLUE PERCH; BERGALL; CHOGSET; NIPPER; WHARF-FISH

Jordan and Evermann, 1896–1900, p. 1577.

Description.—The most distinctive characters of the cunner and the readiest field marks by which it may be distinguished from its close relative, the tautog,

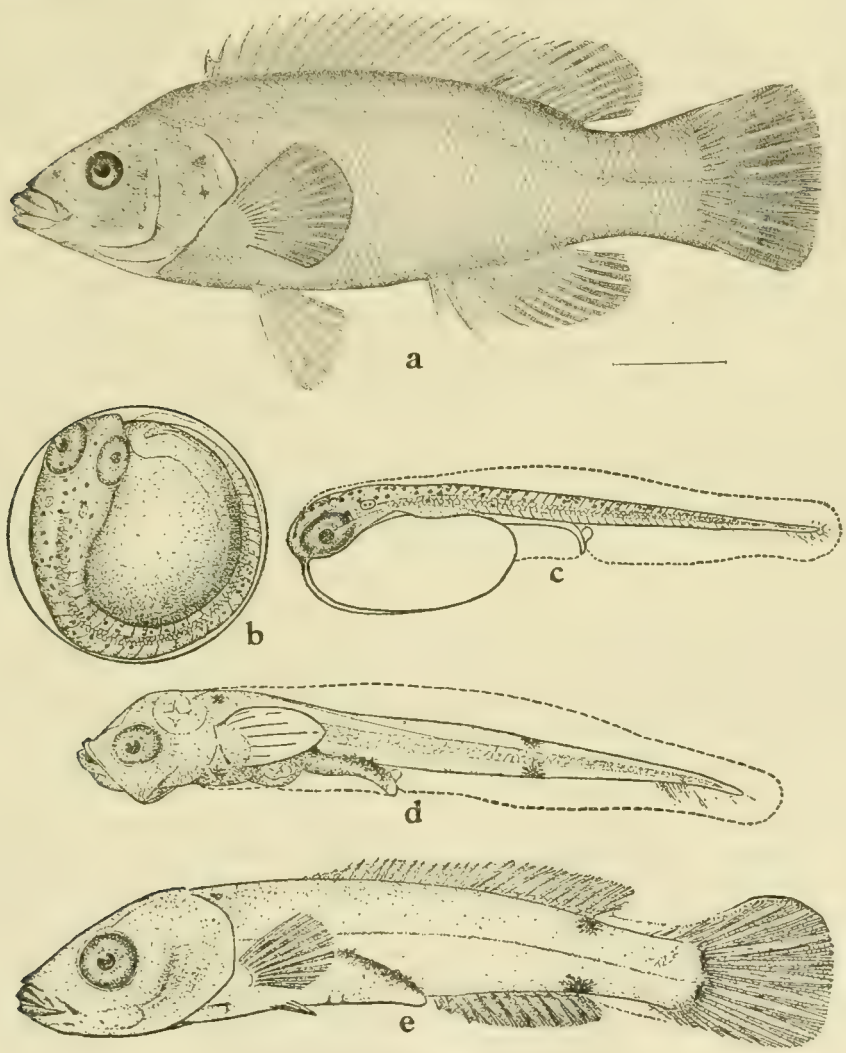

FIG. 131.—Cunner (*Tautogolabrus adspersus*)

a, Adult. *b*, Egg. *c*, Larva, newly hatched, 2.2 millimeters. *d*, Larva, 4.2 millimeters. *e*, Fry, 8 millimeters.

are mentioned above (p. 280). It is moderately deep in body, rather compressed, with a very deep caudal peduncle, flat-topped head (in the tautog the dorsal profile is high arched), small terminal mouth, rather pointed snout, and protractile premaxillaries. Its lips, too, are thinner than those of the tautog. There are several

rows of conical pointed teeth of various sizes in each jaw, the outer ones being very stout. The body and gill covers are covered with large scales (in the tautog there is a naked area in front of the gill opening), and the skin is so tough that the fish must be skinned before marketing. The dorsal fin (about 18 spines and 9 or 10 soft rays) originates over the upper corner of the gill cover in front of the pectoral, and runs back to the caudal peduncle. The first 4 or 5 rays of the dorsal fin are graduated, the others are of about equal length, and the margin of the soft part is rounded. The caudal is slightly convex with rounded corners. The anal (3 stout spines and about 9 rays) originates under or behind the middle of the dorsal and corresponds to the soft part of the latter in outline. The ventrals, and the pectorals, under or slightly behind which they stand, are both of moderate size, and the latter are rounded.

Color.—To describe the color of the cunner is to list all the colors of the bottoms on which it lives, it being one of the most variable of fishes. As a rule the upper parts range between dark or reddish brown with a distinct bluish cast to blue with brownish tinge, variously mottled with blue, brown, and reddish. Some fish, however, are uniform brown; fish caught over mud bottom are often very deep sepia. In some situations they may be dull olive green mingled with blue, brown, or rusty. Some cunners are slaty, but when they are living among red seaweeds about rocks reddish or rusty tones are apt to prevail. Cunners caught in deep water are often almost as red as the rosefish, and on the other hand we have seen very pale ones, more or less speckled all over with blackish dots, over sandy bottom. In our experience (we have handled many hundreds) the belly is invariably of a bluish cast, more or less vivid—sometimes whitish, sometimes dusky, sometimes little paler than the sides. Some cunners have the lips and lining of the mouth bright yellow. Young fry are more or less dark-barred and blotched.

Size.—In the Gulf of Maine adult cunners average about 6 to 10 inches in length and weigh less than half a pound. One foot long is very large, but occasionally they are caught up to 15 inches long, and as heavy as 2½ pounds.

General range.—Atlantic coast of North America and the offshore banks from Labrador and the Gulf of St. Lawrence south in abundance to New Jersey, and occasionally as far as the mouth of Chesapeake Bay.[43]

Occurrence in the Gulf of Maine.—The cunner is perhaps our most familiar fish and one to be found all around the shore line of the Gulf. In Massachusetts Bay they are so numerous along the rocky shores and about ledges that no amount of fishing seems to have any effect on their numbers. They are plentiful over soft and sand bottoms as well, where (at Cohasset, for example), as one drifts along over the flats at low tide, he may see them swimming singly or in companies between the patches of eelgrass. They also swarm about the piles of wharves and under floats in harbors, where they are the joy of small boys and even of older anglers. Cunners run up into the deeper salt creeks, but we have never heard of them in water appreciably brackish. The numbers of cunners vary widely from place to place. The Massachusetts Bay region is perhaps the chief center of abundance

[43] W. C. Schroeder, of the Bureau of Fisheries, informs us that he collected a cunner 59 mm. (about 2⅓ inches) long at Cape Charles, Va., on Sept. 23, 1921, which extends the range of this fish from New Jersey, as noted above.

for the Gulf of Maine. Generally speaking, they are much less numerous east of Casco Bay, and our experience has been that they are progressively less and less plentiful, but average larger, passing east along the shore from Penobscot Bay toward the Bay of Fundy. About Mount Desert, for example, it is unusual to catch one in the inclosed harbors (precisely the localities they frequent farther west and south), and most of those caught outside are very large. I, myself, took many of 12 to 13 inches, averaging about 1½ pounds, near Baker's Island, off Northeast Harbor, in August, 1922, and *no* small ones. Cunners are very rare in the Bay of Fundy and only the largest sizes are ever seen there, though they are known from sundry widely separated Fundian localities. Cunners of all sizes are numerous in St. Mary Bay, at the mouth of the Bay of Fundy but tributary to the open Gulf of Maine, and they are reported along the Nova Scotian shore of the latter and are locally abundant on the outer (southern) coast of Nova Scotia.

The cunner is chiefly a coastwise fish, the great majority of the stock living within a couple of miles of tide mark; and though cunners inhabit offshore as well as inshore grounds, such as Stellwagen Bank, Jeffreys and Cashes Ledges, and even Georges and Browns Banks, where the otter trawls frequently pick up a few, we have never heard of a large catch of them out at sea. They are most abundant from just below tide mark down to 3 or 4 fathoms, and young cunners are often found among eelgrass or in rock pools, but as a rule one finds them running smaller and smaller the farther one goes up any estuary. On the other hand, they are common enough at 10 to 15 fathoms in the inner parts of Massachusetts Bay, and not rare as deep as 25 to 35 fathoms on the offshore ledges and banks. The fish caught deepest are usually very large ones that have probably strayed thither from shoal water and, finding good feeding, remained.

The cunner is a bottom feeder. So far as we know adults never swim on the surface nor depart far from the ground or from the rocks about which they make their homes, nor do they school. Many, it is true, may live together, but they act quite independent of one another, simply congregating because the surroundings are attractive. Cunners, like other rockfish, spend much of the time resting quietly or swimming slowly among the bunches of Irish moss (Chondrus) or fronds of kelp, always on the lookout for food.

Food.—Cunners are omnivorous. As a rule they find a livelihood browsing among weeds, stones, or piles, picking up or biting off barnacles and small blue mussels, with the fragments of which they are often packed full. They devour enormous numbers of amphipods, shrimps, young lobsters, crabs, and other small crustaceans of all kinds, univalve and the smaller bivalve mollusks, hydroids, annelid worms, sometimes small sea urchins, bryozoa, and ascidians, and they occasionally capture small fish such as silversides, sticklebacks, pipefish, mummichogs, and the fry of larger species. Finally, cunner stomachs are often found to contain eelgrass as well as animal food. Small cunner fry taken at Woods Hole were found by Doctor Linton to have fed chiefly on small Crustacea such as copepods, amphipods, and isopods.

The cunner is a busy scavenger in harbors, congregating about any animal refuse, to feed on the latter as well as on the amphipods and other crustaceans

attracted by the same morsels. They are also said to eat fish eggs, and no doubt they do feed to some extent on herring spawn. Our own belief, from long experience, is that cunners are always hungry, no matter what the stage of the tide. Probably more are caught on clams than on any other bait. The little ones are a great nuisance, often stealing the bait as fast as it is offered, and, being a small-mouthed fish, very small hooks are best.

Habits.—Cunners are resident the year round wherever found. The fact that on several occasions great numbers have been found dead on the surface during spells of unusually cold weather is positive evidence that they do not move offshore in winter, as do many species of fish, but at most descend into slightly deeper water to pass the cold season. Most authors have described them as hibernating in the mud, or at least as lying among eelgrass or rocks in a more or less torpid state during the winter, but we find no positive evidence to this effect; on the contrary practical fishermen, among them Capt. L. B. Goodspeed, to whom we are indebted for many notes, inform us that cunners are to be caught in abundance on precisely the same spots in winter as in summer. In fact a few are landed in Boston during the cold months, and the only reason more are not brought in then is that there is little demand for them.

Although its geographic range is so wide in latitude, the cunner is vulnerable both to very low and to very high temperatures. Hazards of the first sort, such as we have just mentioned, are more frequent south of Cape Cod, where the fish are apt to be caught in very shoal water in a sudden freeze, than in the Gulf of Maine, where the constant and active mingling of offshore with coastwise water usually prevents the latter from chilling to the danger point. However, an event of this sort took place in Massachusetts Bay in the winter of 1835, when cunners came ashore in quantities between Marblehead and Gloucester. It is likewise probable that low temperatures limit the breeding range of the cunner, with 55° as about the lower limit to successful reproduction, and that it is owing to the cool water of the Bay of Fundy that none breed there (p. 285). On the other hand it is probably the very high temperature produced by the solar heating of the flats at low tide in some bays that drives the cunners out of certain inclosed ones—Duxbury Bay, for example—in summer.

Breeding habits.—Cunners spawn in June, July, and August in the Gulf of Maine, always close along the coast or over such shoal offshore ledges as Cashes. Whether the few that live on Georges Bank succeed in breeding in such deep water is yet to be learned, but this is not unlikely since the Canadian Fisheries Expedition found cunner eggs over Sable Island Bank. With the fish so common, it is no wonder that its eggs have often been taken in great numbers at our tow-net stations near land in July and August—for example near Race Point, Cape Cod; in Massachusetts Bay (where I have often skimmed them in great numbers in the tideways between the off-lying ledges); and at the mouth of Penobscot Bay, as well as in sundry harbors. We have also towed cunner eggs off the outer shores of Cape Cod, but most of our stations have been located too far out from the land to show the abundance in which the eggs occur in the coastal zone.

Captures of eggs off Libbey Island prove that cunners spawn eastward along the Maine coast nearly to the mouth of the Bay of Fundy, though in diminishing number beyond Penobscot Bay. It is doubtful, however, whether eggs produced along the northern coast of the Gulf east of Mount Desert yield more than a very small proportion of fry, nor do cunners breed successfully in the cold water of the Bay of Fundy, where no small ones are ever seen, though some few eggs are spawned there. However, the Bay of Fundy is simply a gap in the breeding range, for St. Mary Bay is a productive nursery, while both eggs and larvæ were taken at various localities along the outer coast of Nova Scotia and in the southern part of the Gulf of St. Lawrence by the Canadian Fisheries Expedition during the summer of 1915.

The eggs are buoyant, transparent, only 0.75 to 0.85 mm. in diameter, and without an oil globule. In temperatures of 70° to 72° incubation occupies about 40 hours. In the cooler waters of the Gulf of Maine (55° to 65°) probably about 3 days are required for hatching. At hatching the larvæ are about 2 to 2.2 mm. long, with a large yolk sac that is resorbed after about 3 days, by which time the larva has grown to about 2.8 mm. and its mouth is formed. The caudal fin rays are first visible at about 4.2 mm. The vertical fin rays and spines are well developed, the ventrals have appeared (but are still very small), and the head and caudal fin have begun to assume their adult outline at about 8 mm., while at 15 mm. the young cunner is of practically adult form. In newly hatched larvæ the pigment cells are scattered uniformly over head and trunk, but by the 3-mm. stage they gather into a pair of black spots, dorsal and ventral, about half-way between the vent and the base of the caudal rays, which are very characteristic of the species and persist to about the 10 to 20 mm. stage. By the time the fry have grown to about 25 mm. they are as variable in color as their parents (it is on record that Louis Agassiz had sixty colored sketches of small cunners 3 to 4 inches long, of different hues, prepared at Nahant during a single summer).[44]

Larval cunners and small specimens generally are even more closely confined to the coast line than are cunner eggs—so closely, indeed, that it is impossible to represent their localities on a general chart of the Gulf, all the catches of 100 or more having been made either in harbors or at most not a couple of miles from land. The precise records have been published elsewhere.[45]

Rate of growth.—The growth of the cunner has not been traced in detail, but since fry of 1 to 1.2 inches have often been taken in August and young fish up to 2 inches in September in southern New England, we may assume that in the Gulf of Maine the earliest hatched fry grow to 2½ or 3½ inches by the end of the autumn. The 4 to 6 inch fish, so plentiful, are then in their second summer. Cunners mature as young as this, for ripe fish no longer than 3 inches have been taken.

[44] The embryology and larval development of the cunner have been described by Agassiz (1882, p. 290, pls. 13 to 15), Agassiz and Whitman (1885, p. 18, pls. 7–19, and Memoirs, Museum of Comparative Zoology at Harvard College, vol. 40, No. 9, 1915, pls. 32–39), and Kuntz and Radcliffe (1918, p. 99, figs. 18–29).

[45] Bulletin, Museum of Comparative Zoology at Harvard College, Vol. LVIII, No. 2, 1914, p. 108, and Vol. LXI, No. 8, 1917, p. 271.

Commercial importance.—The cunner was once a favorite pan fish, and in the late seventies of the past century the annual catch of the small boats fishing out of Boston was estimated as not much short of 300,000 pounds,[46] while the fact that 104,100 pounds of cunners were returned for Maine in 1889, 148,300 pounds in 1898, and 281,500 pounds in 1905, shows that the annual harvest was still considerable at that time. They seem to have gone so wholly out of fashion since then, however, that very few were marketed in 1907, and these few were sold mostly to the poorer people, while in 1919 the reported catch was only 30,695 pounds for Maine and about 10,000 for the whole shore line of Massachusetts, south as well as north of Cape Cod.

Although not a "game" fish, the humble cunner affords amusement to thousands of vacationists near our large cities and seaside resorts; and the number thus caught, of which no record is kept, is so considerable that it must be classed as a very useful little fish from the recreational standpoint.

107. **Tautog** (*Tautoga onitis* Linnæus)

BLACKFISH

Jordan and Evermann, 1896–1900, p. 596.

Description.—The tautog suggests an overgrown cunner, but it is a heavier, stouter fish (about three times as long as deep, counting caudal) with caudal peduncle so broad and caudal fin so little wider than the peduncle that it is hard to hold a heavy one by the tail. The most obvious differences between the two fish are that the dorsal profile of the head of the tautog is high arched, its nose is very blunt, its lips are much thicker, its eye is high, and its mouth is low, giving it a facial aspect quite different from that of a cunner. A more precise if less obvious character is that the cheek region close in front of the gill opening, scaly in the cunner, is naked and velvety to the touch in the tautog. In relative size and location its fins practically reproduce those of the cunner. The dorsal fin (16 to 17 spines and 10 rays) originates over the upper corner of the gill opening and runs back the whole length of the trunk. The anal (3 stout spines and 10 rays) corresponds in outline to the soft portion of the dorsal, under which it stands. The caudal fin is slightly rounded at the corners, the pectorals are large and rounded, and the ventrals have one stout spine. The soft part of the dorsal fin is considerably higher than the spiny part in the tautog, while it is only slightly so in the cunner. The jaw teeth of the tautog (in two series) are stout, conical, with the two or three in the front of each jaw larger than others. The tautog has, besides, two groups of flat, rounded, crushing teeth in the rear part of the mouth which the cunner also has.

Color.—The tautog is a very dark fish, generally mouse color, chocolate gray, deep dusky green, or blackish, with the sides irregularly mottled or blotched with darker. These mottlings are more evident in the young than in adults and usually occur as three pairs of more or less continuous bars. Large fish are often almost plain. The belly is but slightly paler than the sides. Tautogs, like cunners, vary greatly in color on different bottoms, and also in their markings.

[46] Unfortunately published statistics throw little light on the actual catch of cunners, for not only are many consumed locally, but the fishery is such that only a fraction of the catch is reported.

Size.—Maximum length about 3 feet. The 22½-pounder, 36½ inches long, mentioned by Goode (1888) as caught off New York in 1876 and preserved in the United States National Museum, still remains the heaviest fish definitely recorded. This was a monster, fish over 14 pounds being very rare, with 12-pounders unusual. As they come to market tautog average hardly more than 2 or 3 pounds.

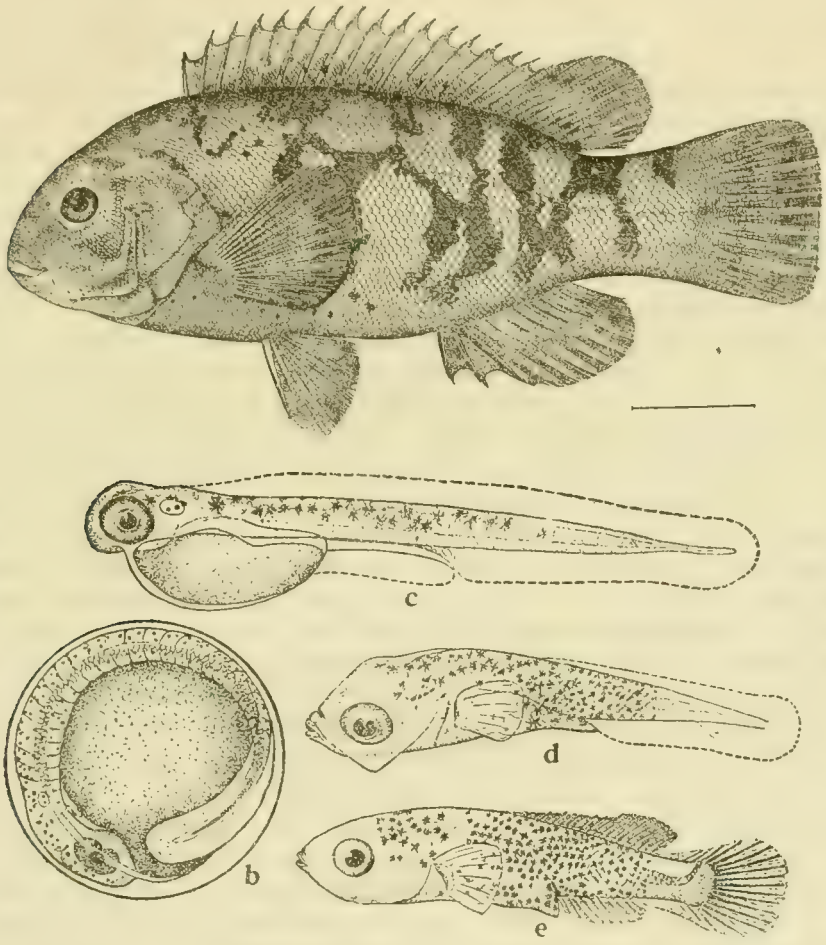

FIG. 132.—Tautog (*Tautoga onitis*)

a, Adult. *b*, Egg. *c*, Larva, 1 day old, 2.9 millimeters. *d*, Larva, 5 millimeters. *e*, Fry, 10 millimeters.

General range.—Atlantic coast of the United States from the Bay of Fundy to South Carolina, chiefly south of Cape Ann, and most abundant between Cape Cod and the Delaware Capes.

Occurrence in the Gulf of Maine.—The tautog is not and never has been a very plentiful fish in the Gulf. Its center of abundance lies farther south. Most authors

who have written of it have accepted without question Mitchill's (1815, p. 400) dictum that it was not native north of Cape Cod but was introduced there shortly prior to 1814; but although we find no definite record of tautog in the Gulf prior to that date it seems to us far more likely that the anonymous writer who stated in the Gloucester Telegraph of May 5, 1860, that tautog were plentiful many years before and had merely reappeared there after a period of scarcity was correct, and that this reappearance would have taken place in any event even if none had been liberated north of Cape Cod. Apart from Mitchill's vague statement that by 1814 tautog had multiplied so that the Boston market then had a full supply (which may have come from south and not north of Cape Cod, for all that is known to the contrary), the first positive record of a Massachusetts Bay specimen is of one caught among the rocks off Cohasset in 1824,[47] which the local fishermen said was a species new to them. By 1839, however, tautog were being caught in numbers in the inner parts of Massachusetts Bay (e. g., Lynn, Nahant, Boston Harbor); they were more abundant about Manomet Headland in Plymouth, and especially so at Wellfleet where they already supported a considerable hook and line fishery. A few years later the presence of this fish was established for the coast of Maine, and in 1851 it was reported common in St. John Harbor, tributary to the Bay of Fundy. According to Perley, however, these Bay of Fundy fish were introduced—not native. In 1876 the weirs north of Cape Cod took 2,274 pounds of tautog, and in 1879 Goode and Beane described it as abundant in many localities about Cape Ann.

At present, or within the last few years (for this fish fluctuates in abundance from year to year), the regular range of the tautog includes the whole coast line from Cape Cod to Cape Ann in suitable localities. North of this it is less regular, less abundant, and more local, but there are some tautog grounds about the Isles of Shoales, off Cape Porpoise, and about Casco Bay. We have also heard of tautog as not uncommon along the ledges off Boothbay Harbor and in Penobscot Bay. East of the latter the tautog is apparently unusual now, and it is so rare in the Bay of Fundy (it has long since vanished from St. John Harbor) that Huntsman learned of but one specimen taken within recent years. Cranberry Head, Nova Scotia,[48] is the most northerly record for the species.

Being an extremely local fish, perhaps more so than any other Gulf of Maine species interesting either to angler or to commercial fisherman, we would require a local acquaintance far more detailed than we can boast to describe its precise haunts along the whole coast of the Gulf. In Massachusetts Bay the more prolific tautog grounds are, so far as we know, off Wellfleet, Sandwich, Manomet Headland, Gurnet Point at Duxbury, Cohasset, Swampscott, Nahant, Marblehead, Magnolia, and here and there along the rocky shores from Gloucester Harbor to Cape Ann. Following are listed the returns from traps at various localities around Massachusetts Bay for 1915—a good tautog year.

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[47] Goode, et al., 1884.

[48] Fowler, Proceedings, Academy of Natural Sciences of Philadelphia, Vol. LXVII, 1915 (1916), p. 517, Philadelphia.

Locality	Pounds
Provincetown	206
Eastham	271
Truro	2,834
Brewster	189
Wellfleet	527
Sandwich	[49] 18,100
Sagamore	9,044
Nahant	501
Manchester	11
Gloucester	212

A few tautog are taken in one or other of these traps every summer though seldom in such numbers or at as many localities as in 1915.

Only on particular rocks is it worth while to fish for tautogs. In other places apparently equally favorable and harboring as many cunners never a tautog is to be caught. But even though they gather and linger only at certain choice spots they must travel along shore a good deal to account for their capture at so many localities in traps few if any of which are situated on or near the rocky or bowlder-strewn bottom which tautog usually frequent in the Gulf.

Habits.—The habits of the tautog being such that the catches of the traps are usually insignificant, and with no regular commercial fishery for it north of Cape Cod, published statistics throw little light on the yearly fluctuations of the local stock. As far as they go, however, they suggest a decrease during the past 20 years, for the commercial catch by all methods for the coast line of Massachusetts notrh of Boston fell from 2,200 pounds in 1902 and over 5,000 pounds in 1915, to only 158 pounds in 1919. This is in line with the fact that all along the coast of Massachusetts, after the almost Arctic winter of 1918, tautog were reported very scarce, but they seem to have increased somewhat in 1920 and 1921. It is not surprising that fluctuations in the stock of tautog should parallel the character of our winters, warm or cold, for great numbers of them are sometimes chilled and killed along the southern shore of Massachusetts and off Rhode Island by unusually severe winter weather, as happened in 1841, 1857, 1875, February, 1901, and no doubt on many other occasions that have not found their way into print or into the records of the Bureau of Fisheries.

Although tautog are seldom seen before well into April or after November, they are year-round residents off the southern shores of New England. It is well established that they merely drop off into slightly deeper water in winter to spend the cold season among eelgrass, often buried in the mud, lying in the crevices of rocks, or, in the case of the young ones, in empty oyster and clam shells, usually in a torpid state, moving and feeding little, but occasionally they have been caught in lobster pots or on hook and line off Rhode Island even in winter. The vent of this fish has been said to close over in winter—a most unlikely event for which there is no definite evidence.

[49] The accuracy of this item is questionable. Perhaps part of the catch was from the Vineyard Sound, not the Massachusetts Bay, shore.

We have not been able to learn of a tautog taken anywhere in the Gulf of Maine between the first part of November and the last week in May,[50] with very few caught before July. It is a question whether this fish is as strictly resident in the Gulf as it is farther south. Its nonmigrating habit elsewhere is a point in favor of such a supposition, but the fact that successful breeding is yet to be demonstrated for the Gulf of Maine, that no tautog less than 3 to 4 inches long has been credibly reported north of Provincetown, that the fish appear later in the season south than north of Cape Cod and by all reports increase in number as the autumn draws on, and that no winter mortality of tautog has ever been reported in Massachusetts Bay, are opposed to it. Perhaps a few tautog may be reared there, but probably the local stock is more or less recruited every year by migrants from the south, most of which withdraw again to the southward around the Cape in autumn.

In the Gulf of Maine the tautog is found about steep rocky shores and off-lying ledges, or over bowlder-strewn bottoms—seldom in other situations, except that stragglers are sometimes caught about the piers in harbors (of which there is record at Provincetown and Boston), and that the traps pick up a few, as we have just remarked. Breakwaters are favorite haunts, as is the "rip rap" of the recently constructed Cape Cod Canal. South of Cape Cod they are not so strictly confined to rocky bottom and small ones are often seined on sandy beaches, but we have not heard of this happening in Massachusetts Bay. Tautog are strictly coastwise fish. Not only are they unknown on the offshore ledges and banks but it is unusual for one to be caught more than a mile or so from land in the Gulf of Maine, though they are not so closely confined to the coast line farther south. On the other hand it is exceptional for them to run up into brackish water, though an odd tautog has been taken in the tidal part of a stream mouth in Casco Bay; and in the Gulf of Maine they are so closely restricted to the zone from just below tide mark (with the big tides there they are often above low-water mark at high tide), to 3 or 4 fathoms depth, that they are never caught on long lines set for cod or haddock.

Food.—Tautog feed on invertebrates, chiefly on shellfish (both univalves and bivalves), especially mussels and clams, and on barnacles that they pick off the rocks and which are the chief diet of the fishes living about ledges. Hermit crabs are favorite morsels. They also eat sand dollars, scallops, amphipods, shrimps, isopods, crabs, and lobsters, swallowing the smaller whole, but cracking the larger with the crushing teeth (p. 286). A tautog of about 2 pounds caught off Cohasset, Mass., September 3, 1922, had made a meal of Gammarid amphipods ("sand fleas"), though cunners caught at the same time and place were full of barnacles.

Breeding habits.—About Woods Hole the tautog spawn chiefly in June, and the season for such of them as breed north of Cape Cod is probably the early summer. The eggs are buoyant, lacking oil like those of the cunner, but slightly larger (0.9 to 1 mm. in diameter). At a temperature of 68° to 72° incubation occupies 42 to 45 hours and probably 10 to 12 hours longer in the cooler water of Massachusetts Bay. The larvæ[51] are about 2.2 mm. long at hatching. When 4 days old

[50] The earliest date we have found is May 24.

[51] Kuntz and Radcliffe (1918, p. 92) describe its eggs, larvæ, and fry.

(temperature of 68° to 72°) they have grown to 3.3 mm., the yolk has been resorbed, and the mouth is fully formed. Larvæ of 5 mm. show the first traces of the caudal fin rays. At 10 mm. the dorsal and anal fins are differentiated, and by the time the little fish are about 30 mm. long they show the fin forms, deep caudal peduncle, and blunt nose of the adult tautog. The larvæ and youngest fry of tautogs and cunners resemble each other in general form, but the arrangement of the pigment offers a ready means of identification of all but the very earliest stages, for in the tautog the black pigment cells remain more or less uniformly scattered over the whole trunk, whereas in the cunner they soon cluster in the two definite patches described elsewhere (p. 285).

We have found no tautog eggs nor larvæ in our towings in the Gulf of Maine, but being comparatively so scarce a fish and breeding close to the coast, we may simply have missed them. Probably Tracy (1910, p. 137) is correct in assuming that the young of 3 to 6 inches, which may be seined in abundance along the shores of southern New England in summer, are 1 year old, but nothing definite is known of the rate of growth of older tautog, nor at what age they mature.

With so few fish in the Gulf of Maine that can be classed as "game" (that is, affording sport on rod and reel), we may well wish this fish were more plentiful there, for tautog fishing is very good sport indeed.

Commercial importance.—The Gulf of Maine catch is so small that it is of no commercial importance north of Cape Cod, but there is ready sale for all tautog that are brought to market, most people thinking this a very good table fish.

THE JOHN DORIES. FAMILY ZEIDÆ

108. **John Dory** [52] (*Zenopsis ocellatus* Storer)

Jordan and Evermann, 1896–1900, p. 1660.

Description.—The John Dory is easily distinguishable from all other Gulf of Maine fishes of similar body form by its long spines, armor, tiny tail fin, and by the curious outline of its head. Like the butterfish it is very deep (only about one and three-fourths times as long as deep) and very much compressed, rounded in outline, with the dorsal profile of its head noticeably concave, its large mouth set very obliquely, and its caudal peduncle very slender. The dorsal fin is in two parts, spiny and soft rayed, the former originating over the upper corner of the gill cover and having 9 to 10 spines—first, second, and third very long, the others graduated, and all filamentous at the tips. The soft dorsal (26 rays) is considerably longer than the spiny dorsal but less than half as high, and of nearly even height from front to rear. The two dorsals together occupy the entire length of the back of the fish from nape to caudal peduncle. The anal fin (24 rays preceded by 3 short stout

[52] Separable from the common "John Dory" of Europe by three instead of four anal spines, and a greater development of bony plates.

spines) corresponds to the soft dorsal in location, height, and outline. The caudal is brush shaped. The ventrals are very long, with the rays free at their tips, and are situated in front of the pectorals. The latter are short and rounded. The skin is naked except for a series of bony bucklers, each with a hooked spine and arranged as follows: Seven along the base of the dorsal, two in front of the ventrals, one in the midline followed by six pairs between ventrals and anal, and four along the base of the latter.

Color.—Described as plain silvery with a black lateral spot.

FIG. 133.—John Dory (*Zenopsis ocellatus*)

Size.—Six inches long.

Range.—Very little is known of the distribution and nothing of the habits of this fish. It was originally described from a single specimen found at Provincetown, Mass., many years ago (Storer, 1858, p. 386), and was not seen again until November, 1912, when J. T. Nichols, of the American Museum of Natural History, saw half a dozen taken by an otter trawler off New York on the outer part of the Continental Shelf (lat. about 39° 39′; long. 72° 07′) in 52 to 86 fathoms,[53] which is presumably its normal habitat.

[53] The American Museum Journal, Vol. XIII, January, 1913, No. 1, p. 44, amplified by personal letter.

THE TRIGGERFISHES. FAMILY BALISTIDÆ

The triggerfishes are very divergent from the ordinary spiny-rayed fishes anatomically, and their external appearance is so characteristic that they are not apt to be mistaken, unless for their close relatives, the filefishes (p. 294). Their most interesting external characteristics are that the first spine of the first dorsal fin is very much stouter than the others and can be locked erect by the second, and that the large bony scales form a hard armor. Other distinctive features are mentioned below in the description of the Gulf of Maine species. Most of the triggerfishes are purely tropical, and it is only casually that the family enters into the Gulf of Maine fauna. Some of the tropical species are poisonous if eaten.

109. **Triggerfish** (*Balistes carolinensis* Gmelin)

Jordan and Evermann, 1896–1900, p. 1701.

Description.—The readiest field marks of the triggerfish are its deep compressed body and slender caudal peduncle; small terminal mouth with both dorsal and

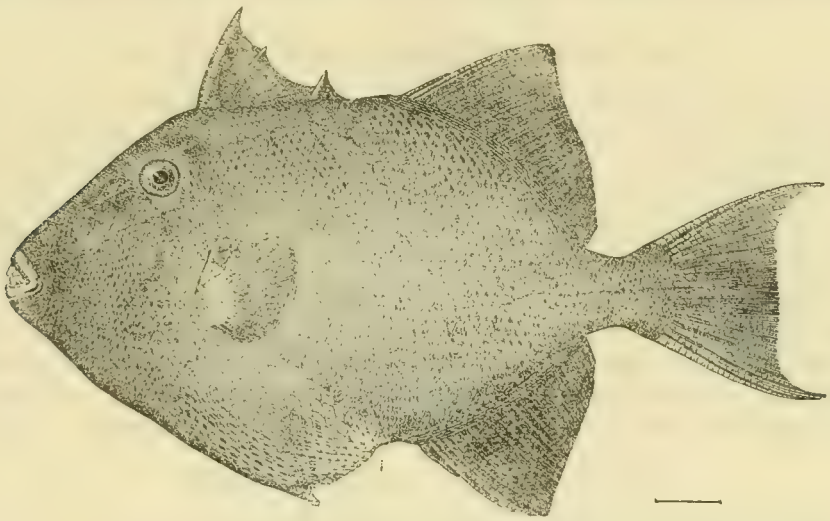

FIG. 134.—Triggerfish (*Balistes carolinensis*)

ventral profiles of the nose nearly straight; eye situated so high as to give its face a very peculiar aspect; large projecting incisor teeth; and especially its unusually stout first dorsal spine; very short gill openings wholly above the insertions of the pectorals; and the plate armor of thick scales with which its entire head and body are clad. The spinous dorsal fin is triangular, with three spines, the first so stout that it is more like a horn, situated close behind the eye and with the second spine acting as a trigger to lock the first erect, whence the common name of the fish. The soft dorsal (27 rays), separated from the first by a considerable interspace, is rhomboid in outline, with the third or fourth rays longest, and tapers back to the base of the caudal peduncle. The anal (25 rays) corresponds to the soft dorsal in outline

and location. The caudal is of moderate size and emarginate in a very characteristic curve. The pectorals are short and rounded and situated below the gill opening. The ventrals are reduced to one short, stout, blunt spine, mostly imbedded in the skin and connected with the general outline of the abdomen by a sort of dewlap.

Color.—Described as olive gray, the back spotted with violet, the sides with two more or less distinct dark crossbars, one under the forward end of the second dorsal, the other under its last ray. The eye is surrounded by a ring of blue or greenish dots and streaks. The first dorsal is clouded with bluish, the second dorsal is pale yellowish marbled with sky blue and olive green, the base of the pectoral is bluish with olive dots, and the anal is like the soft dorsal.

General range.—Both sides of the tropical Atlantic, including the Mediterranean; casual north to Ireland on the European coast, and to the southern coast of Nova Scotia and to Banquereau Bank off Canso on the American coast.

Occurrence in the Gulf of Maine.—A specimen of this warm-water fish was taken at Annisquam, near Gloucester, Mass., many years ago. It is very rare, even at Woods Hole,[54] and only an accidental stray from the south in the Gulf of Maine.

THE FILEFISHES. FAMILY MONACANTHIDÆ

Filefishes recall triggerfishes in general form, being similarly deep and compressed with the same peculiar profiles, small terminal mouths, projecting incisor teeth, eyes set high up, very stout dorsal spines, short gill openings, and in the fact that the ventral fin is either wanting altogether or is reduced to a single short blunt movable spine at the end of the very long pelvic bone, which makes a keel-like continuation of the general ventral profile of the head and is connected with that of the belly by a dewlap of skin. They differ from triggerfishes in having but one dorsal spine instead of three, and in the fact that the scales are so minute that the skin is velvety to the touch although very tough. Most of the species are tropical or subtropical and none has any commercial or sporting value. Adults of the three species known from the Gulf of Maine are separable as follows:

KEY TO GULF OF MAINE FILEFISHES

1. Dorsal spine barbed; gill opening nearly vertical; ventral spine present 2
   Dorsal spine smooth; gill opening very oblique; no ventral spine .....
   ..... Orange filefish (*Alutera schœpfii*), p. 296
2. First soft dorsal ray much elongated and filamentous; caudal peduncle without lateral hook-like spines; ventral flap extends only very slightly behind the ventral spine ...
   ..... Filefish (*Monacanthus hispidus*), p. 295
   First soft dorsal ray not elongate; caudal peduncle with lateral spines, ventral flap extends far behind tip of ventral spine ..... Filefish (*Monacanthus ciliatus*), p. 296

[54] The "leather jacket" (*Balistes vetula*) is more common at Woods Hole and is recorded from Nantucket, but as yet it has not been taken in the Gulf of Maine. It is separable from the triggerfish by the fact that the anterior rays of the soft dorsal and the corners of the caudal are elongated and filamentous, and by the presence of 2 blue bars on each side of the head.

110. **Filefish** (*Monacanthus hispidus* Linnæus)

Jordan and Evermann, 1896–1900, p. 1715.

Description.—In this species the rear margin of the dorsal spine, which is situated over the rear margin of the eye, is armed with a double series of barbs, but the sides of the rounded caudal peduncle bear no spines. The soft dorsal (31 to 33 rays) originates behind the middle of the body, its first ray being much elongated in adults and with a filamentous tip. Otherwise the fin is rounded in outline, narrowing from the front to the rear. The anal (32 to 33 rays) is below the soft dorsal, and of the same shape except that none of its rays are elongate. The caudal fin is rounded. The pectorals are short, rounded, and situated below the gill opening like those of triggerfishes. In the only specimen I have seen the fold of skin that occupies the space between the end of the pelvic bone and the general belly profile—the so-called "ventral flap"— is rounded in outline, not straight as in the illustration, and it extends only slightly behind the tip of the spine.

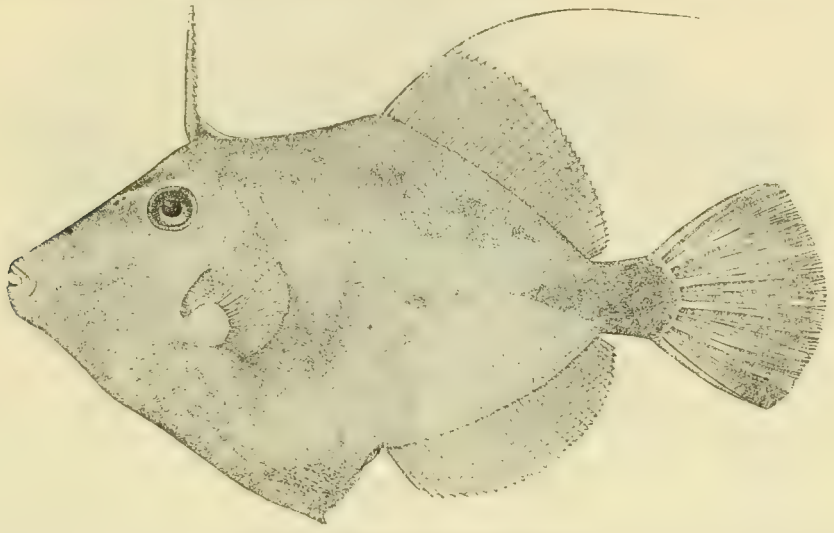

FIG. 135.—Filefish (*Monacanthus hispidus*)

Color.—Green, varying from bright to olive. The back and sides of young fish are mottled with irregular darker blotches but adults are plain colored. Dorsal spine and caudal fin are green. The soft dorsal and anal fins are pale and translucent.

Size.—Maximum length about 10 inches.

General range—A tropical species common on the south Atlantic coast of the United States and in the West Indies. It is known south to Brazil as well as from the Canaries and Madeira in the eastern Atlantic and probably from the East Indies. It is not uncommon as far north as Woods Hole. So far its northern recorded limit has been St. Margarets Bay on the outer coast of Nova Scotia.

Occurrence in the Gulf of Maine.—Odd specimens of this filefish have been recorded from Hingham, Lynn, Nahant, and Boston Harbor in Massachusetts Bay and from Cape Cod, all many years ago. It is only a stray north or east of Cape Cod.

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111. **Filefish** (*Monacanthus ciliatus* Mitchill)

Jordan and Evermann, 1896–1900, p. 1714.

Description.—This filefish closely resembles the species just described, but its first dorsal ray is never elongate, the ventral dewlap extends far behind the tip of the ventral spine, and the caudal peduncle in the adult is armed with 2 or 3 pairs of strong forward-curving spines on either side.

Color.—Described as varying from olive gray and grass green to yellowish brown with darker blotches or crossbands. The dorsal and anal fins are pinkish and usually have three dark spots at the base. The ventral flap is edged with scarlet and the caudal is greenish, mottled dark and pale.

Size.—Four to eight inches long.

General range.—Warmer parts of the Atlantic, from Cape Cod to Brazil on the American coast.

FIG. 136.—Filefish (*Monacanthus ciliatus*)

Occurrence in the Gulf of Maine.—Storer's Massachusetts Bay specimen is still the only record of this filefish within the limits of the Gulf, nor is it known at Woods Hole. It is only a very rare stray in the Gulf of Maine from the south.

112. **Orange filefish** (*Alutera schœpfii* Walbaum)

FOOLFISH; TURBOT; HOGFISH; SUNFISH; UNICORNFISH

Jordan and Evermann, 1896–1900, p. 1718.

Description.—This filefish resembles its relatives of the genus Monacanthus in most respects (p. 294), but while equally compressed it is relatively shallower—not over half as deep as long. The pelvic bone is as elongate as it is in the other filefishes, but there is neither ventral spine nor dewlap, the ventral profile of the body being rounded instead of straight. The eye, too, is set lower down on the side of the head and the gill openings are noticeably oblique instead of nearly vertical.

The dorsal spine is relatively shorter and the lower jaw projects considerably beyond the upper. The soft dorsal (about 36 rays) originates behind the middle of the trunk and is rounded in outline, and the anal (about 36 rays) corresponds to it in size, outline, and position. The short rounded pectorals are situated *below* the oblique gill opening and the caudal is relatively narrower here than in the other filefishes or triggerfishes.

Color.—Described as varying from uniform olive gray to rich orange yellow or milky white above, mottled with darker hues of the same tints; bluish white beneath; the caudal usually yellowish in the adult but sometimes dusky, edged with white.

Size.—Maximum length about 2 feet.

General range.—Atlantic and Gulf coasts of the United States; not uncommon in summer as far north as Cape Cod; casual to Portland, Me.

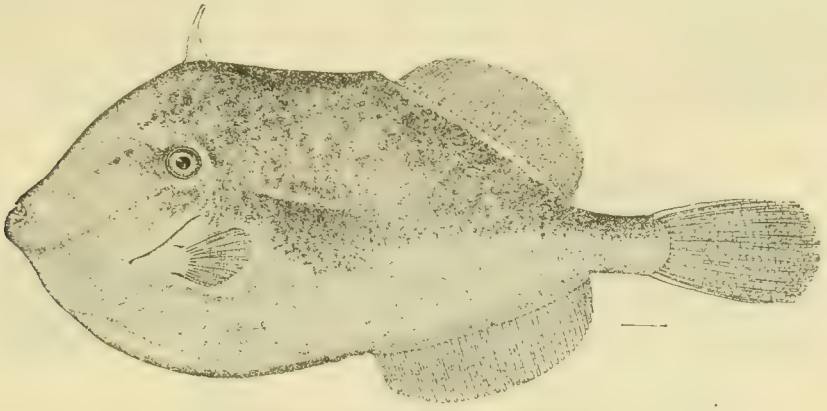

FIG. 137.—Orange filefish (*Alutera schœpfii*)

Occurrence in the Gulf of Maine.—Although the foolfish is not uncommon at Woods Hole during the summer, only three specimens have been reported east of the elbow of Cape Cod—one from Portland, Me., and two from Salem, Mass.—all of them taken many years ago. Evidently it reaches the Gulf of Maine only at long intervals as a waif from the south.

THE PUFFERS AND PORCUPINE-FISHES. FAMILIES TETRAODONTIDÆ AND DIODONTIDÆ

These two families are so closely allied to each other—not only anatomically but in general appearance—that they may be mentioned together. They have but one dorsal fin (the soft rayed), the spiny dorsal being entirely obsolete, and they lack ventrals. Their gill openings are reduced to short slits like those of their allies, the triggerfishes and tilefishes (pp. 293 and 294), their teeth are fused into cutting plates, and they are scaleless. The two families are separable by the structure of the teeth, as described below in the accounts of the two species concerned, and by certain anatomical characters.

KEY TO GULF OF MAINE PUFFERS AND PORCUPINE-FISHES

1. Skin set with large conical spines ..... Burrfish p. 300
   Skin merely prickly ..... Puffer, p. 298

113. **Puffer** (*Spheroides maculatus* Bloch and Schneider)

SWELLFISH; SWELL TOAD; BLOWER; BALLOONFISH; BELLOWSFISH; GLOBEFISH

Jordan and Evermann, 1896–1900, p. 1733.

Description.—When not inflated the puffer is moderately elongate (about three times as long as deep) but not at all compressed, and tapers from abreast the gill opening to a moderately slender caudal peduncle in one direction and to a moderately rounded snout in the other. The very small mouth is situated at the tip of the snout as in the triggerfishes and filefishes. There are no true teeth but the bones of the upper and lower jaws form cutting edges, each divided in the middle by a suture, giving the appearance of two large incisors above and as many below. The gill opening is very small and set oblique, but its obliquity is just the reverse of that of the foolfish (p. 296)—that is, backward and downward. The eyes are set very high and are horizontally oval in outline. The skin is scaleless, but the sides of both head and body, the back from snout to dorsal fin, and the belly as

FIG. 138.—Puffer (*Spheroides maculatus*)

far back as the vent are rough with small, stiff, close-set prickles. The soft dorsal is very short (7 rays), rhomboid in outline, about twice as high as long, and set far back close to the caudal peduncle, with the anal similar to it in shape and size (6 rays) and rising close behind it. There is no spiny dorsal. The caudal fin is of moderate size, slightly rounded, with angular corners. The pectorals are fan-shaped and are situated close behind the gill opening. There are no ventrals. The most interesting morphologic character of the puffer is its ability to inflate itself with air or water until the skin of the belly is stretched tight as a football and the fish is almost globular, and to deflate again at will, when the abdomen shrinks back to its normal dimensions.

Color.—Dark olive green above, sometimes ashy or dusky, the sides greenish yellow to orange, crossbarred with 6 to 8 rather indefinite dark bands or blotches. The belly is white.

Size.—This fish is said to grow to a length of 14 inches, but it is seldom more than 10 inches long. Females average larger than males.

General range.—Atlantic coast of the United States from Florida to Casco Bay; very common as far north as Cape Cod.

Occurrence in the Gulf of Maine.—The center of abundance of this species lies south of the limits of the Gulf of Maine, but it has been taken at Monomoy, Truro, and Provincetown, and is not uncommon in Cape Cod Bay, for Prof. A. E. Gross informs us that he has seen as many as four or five taken in the trap at the mouth of Barnstable Harbor at a tide during the early summer of 1920.[55] We have never heard of one at Cohasset, however; and while Storer described it as common at Nahant, a few miles northeast of Boston, this seems to have been an error, for Wheatland (1852, p. 124), writing about the same period, not only spoke of it as seldom seen in Massachusetts Bay, but considered a single specimen taken in Salem Harbor in the summer of 1848 worthy of note. This still remains the only record for Essex County. There is also a puffer labeled "Massachusetts Bay" in the collection of the Boston Society of Natural History. During the summer of 1896 two puffers were taken in a trap in Casco Bay, this being the northernmost record for the species. It is quite as rare a fish north of Boston as the paucity of this printed record suggests.

Habits and food.—Puffers are summer fish on the southern New England coast, appearing late in May or early in June, to disappear in October or November. They are rarely seen far from land, usually in water only a few fathoms deep, where they feed on small crustaceans of all sorts, especially crabs, shrimp, and amphipods, as well as on small mollusks, worms, barnacles, sea urchins, and other invertebrates, which they find on bottom. Young fry of 7 to 10 mm., examined by Doctor Linton at Woods Hole, had eaten copepods and crustacean and molluscan larvæ.

Puffers inflate on the slightest disturbance, in which state they float, belly up, until they deflate.

It is probable that puffers pass the winter in a more or less quiescent state on the bottom in water slightly deeper than their usual summer haunts. They spawn in summer, from June on, and in shoal water close to shore. The eggs (about 0.9 mm. in diameter, with many small oil globules) sink and stick fast to each other or to whatever they touch. Incubation occupies 4½ to 5 days at a temperature of 67° F. (19.5° C.). The larvæ at hatching are about 2.4 mm. long and brilliantly pigmented with red, orange, yellow, and black. In three days the mouth functions and at 7 days the larvæ are 2.6 mm. long. The later larval stages have not been described, but at a length of 7 mm. the young fish show most of the diagnostic characters of the adults,[56] and can inflate themselves even more—in fact until the bulging skin entirely hides the dorsal and anal fins.

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[55] See also The Auk, Vol. XL, No. 1, January, 1923, p. 24.

[56] Welsh and Breder (Zoologica, Vol. II, No. 12, January, 1922, New York) describe stages in the life history of the puffer.

114. **Burrfish** (*Chilomycterus schœpfi* Walbaum)

PORCUPINEFISH; RABBITFISH; OYSTERFISH

Jordan and Evermann, 1896–1900, p. 1748.

Description.—The burrfish resembles the puffer (p. 298) in general appearance and in the location of its dorsal and anal fins, but its skin is armed with short, stout, triangular spines instead of being merely prickly. These spines are sparsely scattered all over the trunk, with about 9 or 10 from nose to tail along any given line. Furthermore, the burrfish is oval in outline, not fusiform like the puffer; the openings of its nostrils are prolonged in a single tubular tentacle; the bony jaw plates are not divided by a median suture as they are in the puffer—hence each jaw apparently is armed with a single very broad incisor instead of with two; the pectoral fin is not only much larger than in the puffer but is situated behind instead of below the gill opening; the eye is round, not oval; and the anal fin is below, not behind the dorsal. We need only note in addition that these two fins (there is no spiny dorsal)

FIG. 139.—Burrfish (*Chilomycterus schœpfii*)

are both rounded and of 10 to 12 rays, the caudal is very narrow and round-tipped, the pectorals are much broader than long, and that there are no ventrals.

Color.—The ground color varies from green to olive or brownish above, with pale, usually yellow tinted, belly. The back and sides are irregularly striped with olive brown, dusky, or black lines that run roughly parallel with one another and obliquely downward and backward. There is a dark blotch on each side at the base of the dorsal fin, a smaller one between the latter and the anal, one above the base of the pectoral, and a fourth close behind the latter fin.

Size.—Length to 10 inches.

General range.—Coast of the United States, Massachusetts Bay to Florida; plentiful from the Carolinas southward.

Occurrence in the Gulf of Maine.—A specimen from Massachusetts Bay now in the collection of the Boston Society of Natural History affords the only record of this southern fish in the Gulf. Like so many other southern species it is only a chance stray to the Gulf of Maine.

THE HEADFISHES. FAMILY MOLIDÆ

Although the headfishes or sea sunfishes are allied anatomically to the puffers and porcupine fishes, with which they agree in the very small gill openings and in the fusion of the teeth into a sort of bony beak, they bear no resemblance whatever to them in general appearance, apparently consisting of nothing but a "huge head to which the fins are attached," as Jordan and Evermann (1896-1900, p. 1752) aptly express it. There is no spiny dorsal, the soft dorsal and anal are short and very high, and there is no caudal peduncle. The caudal fin, so short that it is apparently nothing more than a flap of skin, extends around the rear outline of the trunk. Corresponding to their extraordinary conformation the sunfishes have only 16 or 17 vertebræ.

115. **Sunfish** (*Mola mola* Linnæus)

Jordan and Evermann, 1896–1900, p. 1753.

Description.—In its general appearance the oblong body of an adult sunfish—and adults alone are seen regularly in the Gulf—suggests the head and fore trunk of

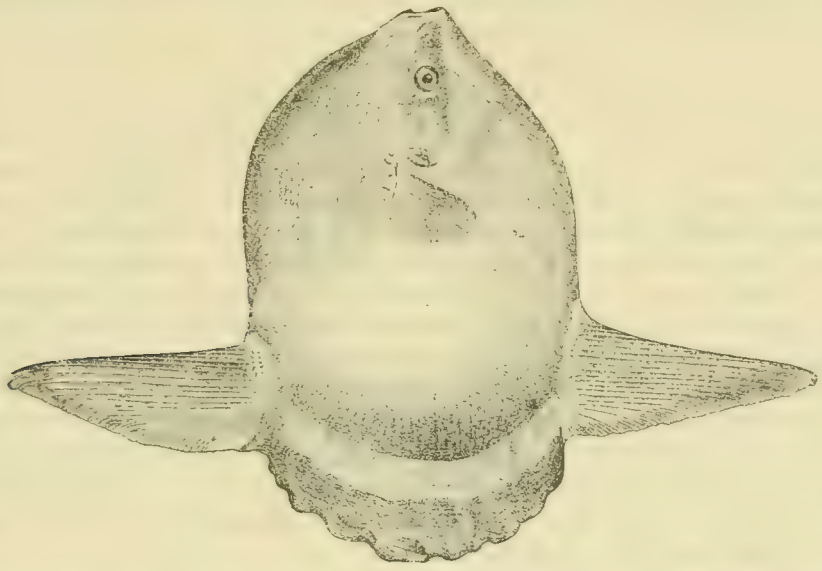

FIG. 140.—Sunfish (*Mola mola*)

some enormous fish cut off short, the oblong body being truncate immediately back of the dorsal and anal fins and without caudal peduncle. In front of the fins, however, it tapers toward the snout so that the forward half of the trunk is oval in profile. The fish is less than twice as long as deep, strongly compressed (about one-fourth as thick as deep), with a very small terminal mouth, teeth completely united in each jaw, a very small eye in line with the mouth, and remarkably short gill openings, while the nose overhangs the upper jaw as a kind of rough, mobile wart or pad. The soft dorsal (there is no spiny dorsal) and anal fins stand one over the other close behind the middle of the fish. Both are very much higher than long, triangular, with rounded tips, consisting of 15 to 18 rays, the seventh ray being

the longest. The fins can not be depressed, as in most bony fishes, but the sunfish sculls itself along by waving them from side to side. The caudal fin extends around the whole posterior margin of the body. In the young it is confluent with the dorsal and anal fins and is hardly separated from them in the adult—so short and with its rays so hidden by the thick opaque skin that it looks more like a dermal fold than a typical fin. Its general outline is rounded, paralleling the rear outline of the body, but its margin is scalloped in the line of each ray (11 to 14) by a rounded bony thickening in a notch. We have counted 11 such notches in a fish 3½ feet long. The pectoral fin is small, rounded, and situated about halfway up the body immediately behind the tiny gill opening. There are no ventrals. The skin is unusually thick (about 1½ inches in one 47 inches long which we harpooned near La Have Bank on August 7, 1914), very tough and elastic in texture, and crisscrossed with low ridges, while fins as well as trunk are clothed with small bony tubercles, giving the appearance of shark skin.

The sunfish is described as glowing phosphorescent at night in the water. This, however, we can not verify first hand, but we can bear witness that it grunts or groans when hauled out of the water, that its skin is covered with a thick layer of tough slime, and that it is the host of a great variety of parasites, external and internal, with copepods and trematodes clinging to its skin and infesting its gills, its muscles harboring round worms and its intestines various round and flat worms.

Color.—Dark gray above, the back with a brownish cast, the sides paler with silvery reflections, the belly dusky to dirty white. Some descriptions mention a broad blackish bar along the bases of the unpaired fins, but nothing of the sort was to be seen in the only example we have handled fresh from the water.

Size.—The sunfish grows to a great size. Heilner[57] describes the capture of one 10 feet 11 inches long off Avalon (California), while Jordan and Evermann record another Californian specimen 8 feet 2 inches in length, weighing about 1,800 pounds. One measuring 8 feet in length and 11 feet from tip to tip was exhibited in London in 1883,[58] and an 8-foot specimen was taken off Cape Lookout (North Carolina) in 1904,[59] but such monsters as this are quite exceptional, the general run being from 3 to 5 feet (very rarely 6 feet) long and 175 to 500 pounds in weight. A fish 4½ feet long is about 31 inches across the body and 6½ feet from the tip of the dorsal fin to the tip of the anal. A fish 4 feet 1 inch long, caught off Boston Harbor on August 14, 1922, scaled 516 pounds.[60]

General range.—Oceanic and cosmopolitan in tropical and temperate seas; known northward to northern Norway on the European side of the Atlantic, to the Newfoundland banks and outer coast of Nova Scotia on the American side, and recorded from the Gulf of St. Lawrence as well.

Occurrence in the Gulf of Maine.—The sunfish is only a casual visitor to the Gulf, which it enters now and then from the warmer and more congenial waters outside the continental slope. Every year odd sunfish are reported here or there

[57] Bulletin, New York Zoological Society, Vol. XXIII, No. 6, November, 1920, p. 126.
[58] Smitt. Scandinavian Fishes, 1892, p. 626.
[59] Smith. North Carolina Geological and Economic Survey, Vol. II, 1907. Raleigh.
[60] Reported, with photograph, in the Boston Daily Post for Aug. 14, 1922.

within the limits of the Gulf. There are printed records of it in St. John Harbor in the Bay of Fundy; near Seguin Island, off Small Point, and off Cape Elizabeth (Maine), where it has been reported repeatedly; off Cape Ann; and from various localities in Massachusetts Bay. Sunfish have even been seen in Boston Harbor, and on August 18, 1918, one 4½ feet long was killed in a narrow creek at Quincy, Mass. The *Grampus* sighted sunfish near the Isles of Shoals in 1896 (Doctor Kendall's field notes), in 1912, and in 1914, one in the eastern basin of the gulf in 1912, and seaside dwellers reported one or two near Cape Porpoise in 1921. In short, as many fishermen have told us, sunfish may be expected anywhere in the Gulf and even right up to the land, but so few visit the inner parts that to see one is always something of an event. During July and August of 1912, for example, the *Grampus* sighted only one, none at all in August, 1913, and only one in the Gulf and another near La Have Bank during the mid and late summer of 1914. Report has it, however (we can not verify this from first-hand observation), that sunfish are more plentiful over and along the southern edge of Georges Bank, as indeed might be expected from their oceanic origin. In the inner parts of the Gulf it seems that sunfish are most often seen in midsummer and usually some distance offshore. When sighted, these unlucky vagrants have usually been chilled into partial insensibility, floating awash on the surface, feebly fanning with one or the other fin, the personification of helplessness. Usually they pay no attention to the approach of a dory, but we have seen one "come to life" with surprising suddenness and sound swiftly, sculling with strong fin strokes, just before we came within harpoon range. When one is struck it struggles and thrashes vigorously while the tackle is being slung to hoist it aboard, suggesting that they are far more active in their native haunts than their feeble movements in fatally cold surroundings might suggest.

Habits and food.—The sunfish lives on an unusual diet, for as a rule the contents of the stomach consists either of jellyfish, ctenophores, or salpæ, or of a slimy liquid that probably represents their partially digested remains. This has been the case with all the sunfish brought in to the Bureau of Fisheries at Woods Hole; but various crustacean, molluscan, hydroid, and serpent-star remains, even bits of algæ and eelgrass (Zostera), have been found in sunfish stomachs in European waters, proving that at times it either feeds on the bottom in shoal water or among patches of floating weed, and certainly its jaws seem fit for harder food than jellyfish.

There is no reason to suppose that the sunfish ever breeds in the Gulf of Maine, but Putnam (1870b, p. 255) records young ones about 2 inches long from Massachusetts Bay.[61] Its spawning habits are not known, but presumably the eggs are buoyant, with many oil globules, such being the case with the closely allied species, *Mola lanceolata*. The young sunfish is spiny and very different in appearance from the adult.

Commercial importance.—This is a worthless fish, neither edible nor oily enough to be worth trying out, even could enough of them be caught.

[61] Schmidt (Meddelelser fra Kommissionen for Havundersøgelser, Serie, Fiskeri, Bind VI, 1921, No. 6, p. 11) believes these were *M. lanceolata*, not *M. mola*.

THE ROCKFISHES. FAMILY SCORPÆNIDÆ

Although the rockfishes are perchlike or basslike in general appearance they are actually related to the sculpins (p. 314) and sea robins (p. 344) by the fact that a bony stay (an extension of one of the suborbital bones) stretches right across the cheek, giving the latter a characteristic bony appearance. Furthermore the cheeks are spiny, and in most of the species the top of the head is marked by ridges that terminate in spines. Both spiny and soft portions of the dorsal are well developed, either as a continuous fin or subdivided by a deep notch. The ventrals are thoracic. There are many species, the temperate Pacific being especially rich in them, but only one occurs regularly in the Gulf of Maine, with a second appearing as a stray in the southwest corner of the area covered by this report.

KEY TO GULF OF MAINE ROCKFISHES

1. The lower rays of the pectoral fin are not free. There are 15 dorsal spines----------Rosefish, p. 304

   The lower 8 pectoral rays are free for the outer half of their length. There are only 12 dorsal spines----------Black-bellied rosefish, p. 313

116. **Rosefish** (*Sebastes marinus* Linnæus)

REDFISH; RED BREAM; RED PERCH; NORWAY HADDOCK

Jordan and Evermann, 1896–1900, p. 1760.

Description.—The rosefish is perchlike in general appearance, moderately compressed, about one-third as deep as long, with large bony head, and tapers back from the shoulders to a moderately slender caudal peduncle. The dorsal profile of the head is concave, the mouth is large, very oblique, and gapes to below the eye, the lower jaw projects, and there is a bony knob at its tip fitting into a corresponding notch in the upper. Both jaws are armed with small teeth. The eye is very large and set high. The sides of the head are armed with spines, of which two near the gill cover and a series of five confluent ones on each cheek are the most prominent. These, with a ridge behind and above each eye socket, give the head a "bony" appearance that is extremely characteristic. The gill opening is very wide, with pointed gill cover. There is one continuous dorsal fin running from nape to caudal peduncle, the spiny part (14 to 15 spines) considerably longer than the soft part (13 to 15 rays), but the latter higher than the former. The precise outline is easier illustrated (fig. 141) than described verbally. The anal, consisting of three graduated spines and seven longer rays, is shorter than the soft portion of the dorsal, under which it stands. The caudal is relatively small, slightly emarginate, and with angular corners. The pectorals are very large, and the smaller ventrals are situated below them. Both head and body are clad with scales of moderate size.

The rosefish agrees with the cunner, tautog, and sea bass in the combination of the spiny and soft portions of its dorsal into a single long fin and in its generally perchlike conformation. Apart from its brilliant color, however, which is of itself a sufficient field mark, it is separable from the first two by its much larger mouth,

spiny head, large eye, more slender caudal peduncle, and larger pectoral; and from the sea bass by its large spiny head, the small size and outline of its caudal fin, and by the fact that its anal and the soft portion of its dorsal are relatively much lower.

Color.—Orange to flame red, rarely varying to grayish or brownish red, with the belly a paler red fading to white after death. Sometimes there is a dusky blotch on the gill cover and irregular dusky patches on the back. The black eyes make a vivid contrast to its brightly colored body.

Size.—On the other side of the Atlantic and in Arctic seas the rosefish grows to a length of 3 feet or more,[62] but about 2 feet and a weight of 12 to 14 pounds seems to be about the maximum off the American coast. In European waters there are two forms of this fish (intergrading, however)—a larger offshore and a smaller in shoal water inshore. American fish also run much smaller near the coast (usually 8 to 12 inches long) than on the offshore banks.

General range.—Both sides of the North Atlantic and in Arctic seas, north to Spitzbergen, Nova Zembla, Greenland, Davis Straits, and Labrador. Off the American coast it occurs as far south as New Jersey in deep water.

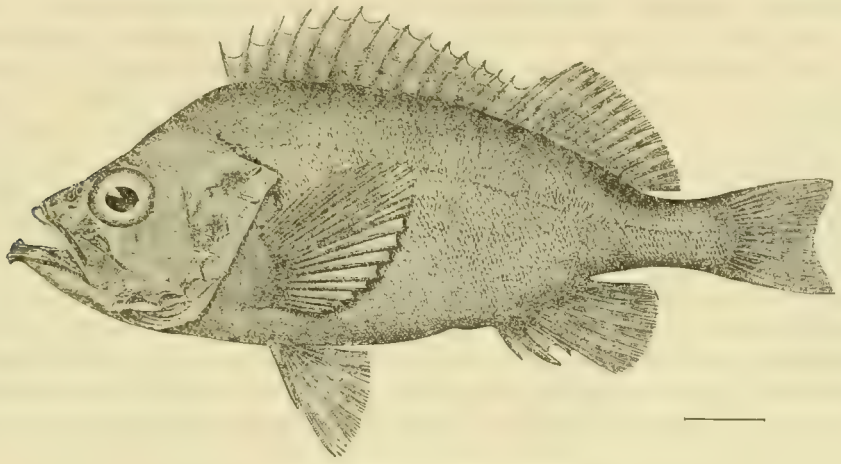

FIG. 141.—Rosefish (*Sebastes marinus*).

Occurrence in the Gulf of Maine.—This is a fairly common fish in all but the shoalest parts of the Gulf, alike on the offshore banks, in or over the deep central basin, and along shore. To list its known occurrences would be to mention practically every station where hook-and-line or otter-trawl fishing is carried on at more than 20 fathoms depth. Thus considerable numbers are sometimes taken on lines or trawls in 15 to 20 fathoms or more in Massachusetts Bay both winter and summer, especially on or near rocky bottom, while we ourselves have trawled it in 27 to 33 fathoms off Gloucester and off Boston Harbor. Many are caught along the northern shore of the bay, also, as well as on and near Jeffreys Ledge and between Cape Ann and Boon Island. The fact that the *Grampus* took rosefish in 6 out of 7 hauls in 25 to 60 fathoms between Cape Ann and Penobscot Bay in July, 1912, with a trawl

[62] It has been said to reach 4 feet.

only 8 feet across the mouth, shows how universal they are in this part of the Gulf in suitable depths. But whether in trawl nets, gill nets, or by hook and line, the catches are always small compared to those of haddock and pollock. Unfortunately the published fisheries statistics throw little light on their actual abundance along the coast of Maine, for not being an important market fish, they do not appear at all in the general surveys for the years 1898, 1902, or 1905, while it is certain that only a small part of the catch was reported in 1899 (as "bream") or in 1919 (as "rosefish"). However, returns of about 27,000 pounds between Cape Elizabeth and Penobscot Bay in the latter year corroborate the statement that rosefish are to be found in plenty all along the northern shores of the Gulf in depths of 25 fathoms or more. They are also common in the Bay of Fundy, even in such inclosed waters as Passamaquoddy Bay and the mouth of the St. Croix River. Huntsman found them in St. Mary Bay, they are well known along western Nova Scotia, have been reported near Seal Island, and are plentiful on the neighboring fishing grounds generally.

Habits.—In the southwestern part of the Gulf rosefish are found only below 15 to 20 fathoms depth during the summer. So few, for instance, are taken in the Massachusetts Bay traps that they do not figure in the local returns, though recorded for Provincetown. Goode, et al. (1884), long ago described them as coming right up to the docks in the northern parts of the Gulf (presumably at Eastport) with cunners and sculpins, even during the warm months. The collection of the Museum of Comparative Zoology contains many small rosefish 2 to 6 inches long taken in that harbor probably in summer or autumn, and according to Huntsman they occur in Passamaquoddy Bay at that season in water no deeper than 5 fathoms. This local difference in vertical distribution suggests that the rosefish shuns temperatures warmer than about 50°, which is corroborated by the fact that they have been known to run up into Gloucester Harbor in great numbers in winter [63] but never in summer; and although we have not heard of them in numbers in any other harbor south of Cape Elizabeth, the frequency with which they are taken in the gill nets early in spring suggests a general winter migration into water shoaler than the summer haunts, succeeded by a movement out into deeper water at the approach of warm weather.

Rosefish living in water shoaler than 50 fathoms are mostly on bottom—witness the catches on line trawls (p. 305)—chiefly on rock or on mud, and seldom, if ever, on sand. It does not necessarily follow, however, that they hug the bottom as closely in the deep central basin of the Gulf, where the presence of this fish is attested not only by fishermen who catch them when setting for hake but by the abundance of fry (p. 309), but where the ground is soft sticky mud, for rosefish live bathypelagic over deep water both in the Gulf of St. Lawrence and in north European waters. Practical fishing experiments alone can settle this point.

Rosefish are more abundant locally and at certain times on Georges Bank (from report this applies to Browns, also) than near land. For example, Welsh noted 240 taken on Georges in the four days June 20 to 26, 1912. The schedules of the otter-trawl investigations of 1913 list 3,887 rosefish as caught in 22 successive hauls on Georges Bank from September 26 to 30 (that is, more than one-third as

[63] Goode, et al., 1884.

many as haddock); 11,592 (nearly as many as haddock) at about the same locality in the three days, October 10 to 13; 4,267 during a four-day trip to the South Channel, from October 23 to 27; and 12,191 in the same general locality in six days two weeks later (November 9 to 15). During the year in question rosefish formed 1.8 per cent of the total catch of fish of all kinds by several trawlers operating on Georges Bank during the months June to December, and 5.9 per cent in South Channel, which is a better index to the relative abundance of the fish than the annual landings from the Banks (30,000 to 50,000 pounds in 1915), for the larger part of the catch is thrown away because the market will not absorb it.

In 1913 not a single rosefish was scheduled for Georges Bank between December 1 and mid June,[64] with all the largest catches occurring in September, October, and November, but inasmuch as all the winter trips were to the eastern, southeastern, and central parts of the bank, all the trips reporting large hauls of the fish either to its western and northwestern portions or to the South Channel, the precise locality where fishing was carried on and not the time of year may have been the factor governing whether rosefish were caught or not. Seeing that 1,400 were caught on April 4 on Brown's Bank in two sets of a line trawl, we doubt whether there is any periodicity in the presence of rosefish on these offshore grounds.

Rosefish inhabit a wide range of temperature. The maximum may be set at about 48° to 50°, and probably it is the seasonal warming of the surface stratum that drives them to summer in deep water off the coasts of Maine and Massachusetts, whereas the low surface temperature of parts of the Bay of Fundy, where the upper 10 fathoms or so may be as cool as 50° even in midsummer, allows them to remain in shoal water there the year round as just noted (p. 306). At the other extreme they winter in Massachusetts Bay and in Passamaquoddy Bay in water as cold as 33° to 35°, and perhaps colder, though they could easily escape from these low temperatures by a short offshore migration. In fact, the rosefish has often been described as an "Arctic" species, but while this is true to the extent that its range extends to Arctic Seas, we are convinced that this is a misnomer if taken to mean that it is characteristic of Polar temperatures, the records of its occurrence, horizontal and bathymetric, proving that though it is able to survive any temperature down to freezing when adult, the great majority of rosefish inhabit waters warmer than, say, 35°, and over the greater part of their geographic range.

The distribution of this fish in the Gulf of St. Lawrence is especially instructive in this respect, for there it is characteristic of the comparatively warm water (39° to 42°) in the bottom of the deep channels,[65] not of the icy intermediate layer (about 32°) which, generally speaking, is so nearly an impassible barrier to its upward migration that it is seldom if ever taken on the shoal banks. Its bathymetric range in relation to temperature is apparently much the same off the west coast of Greenland. Here Fabricius [66] long ago described it as confined to water so deep that when one accidentally comes to the surface it is "poke blown" and dies, while Jensen,[67] who has recently published an interesting study of the rosefish in Greenland

[64] This takes account only of the vessels that carried observers from the Bureau of Fisheries.
[65] Huntsman, 1918a, p. 63.
[66] Fauna Groenlandica, 1780, pp. 167–169.
[67] Videnskabelige Meddelelser fra Dansk naturhistorisk Forening i Kjøbenhavn, Bind 74, 1922, pp. 89–109.

seas, states that it is very seldom taken shoaler than 75 fathoms there and chiefly below 90 fathoms. That is to say, they are living at about 37° to 39° [68]—not in the coldest layer—and in west Greenland, says Jensen, numbers of them sometimes come to the surface dead in winter, apparently having succumbed to cold. The fishery experiments of the Norwegian fisheries steamer *Michael Sars*[69] have proven that the rosefish is no more characteristic of Arctic temperatures on the European than on the American side of the Atlantic, for while its geographic range extends far to the north, indeed right up to Nova Zembla and Spitzbergen, it is caught there only in the overlying layer of Atlantic water at temperatures of 39° to 43°, never in the colder Polar water deeper down, though the latter supports typically Arctic fishes in abundance. It is worth emphasizing that in thus avoiding Polar temperatures the rosefish occupies very different bathymetric zones in the Gulf of St. Lawrence and in west Greenland waters on the one hand, where it is confined to the bottom stratum, than off northern Europe on the other.

This is perhaps an appropriate place to note that there is no positive record of the rosefish from the east coast of Labrador, north of the Straits of Belle Isle, Packard's young specimens (dredged in 15 fathoms) being as likely from the north shore of the Gulf of St. Lawrence. It therefore remains to be seen whether it is endemic in the undiluted Polar water of the Labrador current, and for this same reason it is most desirable to establish its status on the east coast of Newfoundland more definitely than can be done from data yet available.

Food.—The diet of the rosefish includes a great variety of crustaceans, especially mysids and euphausiids, shrimps, small mollusks, and various other invertebrates as well as small fish, and it bites on any bait. In turn it is itself the prey of all larger predaceous fish, its fry being devoured in quantity by cod, older rosefish, and halibut.

Breeding habits.—It has long been known that this fish is viviparous, the eggs developing and hatching within the oviduct of the mother. It is not likely that any rosefish are born in the Gulf of Maine before late May, for we have found no gravid females or larvæ prior to the end of that month. Breeding is evidently well under way in June, for not only did Welsh see several mother fish containing well-developed young taken on Georges Bank from the 20th to 26th in 1912, but we have towed a few newborn fish (7 to 10 mm.) off Boothbay and Mount Desert on May 31 and June 14. July 8, however, is the earliest that we have taken them in any numbers in our tow nets (57 larvæ off Cape Cod in 1913), with July and August covering the height of the breeding season and with very few young produced after the first week of September, while our latest seasonal record for young rosefish (a single specimen from Southwest Harbor) is for the 14th of that month. Previous authors have similarly described it as breeding from June to September off Massachusetts, and most of the Canadian records of rosefish larvæ, both within and without the Gulf of St. Lawrence, are likewise for late June, July, and the first half of August. In north European waters young rosefish are produced over a longer period—from mid-April through August, according to locality.

[68] See The Danish Ingolf-Expedition, Vol. I, Part 2, 1899, for temperatures in this general region.

[69] Captured in abundance on line trawls suspended at 50 to 100 fathoms over much greater depths in the northern part of the Norwegian Sea. Murray and Hjort, The Depths of the Ocean, 1912, pp. 435, 648. London.

The fact that we have taken the pelagic young of this species in our tow nets at many localities distributed over the whole northern part of the Gulf, both in deep water and in shallow (even Southwest Harbor on Mount Desert Island), instead of concentrated in shoal water in the southwest corner as is the case with larval gadoids (p. 437) and flatfish, is sufficient evidence that rosefish breed indifferently wherever found and do not gather in special localities for this purpose.

Fig. 142.—Localities where larval rosefish have been taken in the tow net. ○, less than 100; ●, 100 or more.

The rosefish, unlike most of the fishes producing buoyant eggs, breeds successfully in the Bay of Fundy, the pelagic larvæ of this species having been found at the mouth of the bay and for some distance up the center during the late summer.[70]

We have only one record of very young rosefish on Georges Bank. Indeed, we have found very few anywhere south of a line from Cape Cod to Cape Sable (fig. 142), but the presence of gravid females on the bank (p. 308), together with the local abundance of large fish there, suggests that it is none the less an important

[70] Huntsman, 1922a.

breeding ground. The rosefish reproduces considerably farther west than this on the outer edge of the continental shelf, for thousands of young fry, as well as adults full of spawn, were collected in 100 to 180 fathoms off the southern coast of New England during the early years of the United States Bureau of Fisheries.

Although we have found rosefish larvæ so universal over the offshore parts of the Gulf, the notable centers of abundance have all been located within a few miles, one side or the other, of the 50-fathom contour, whether it be the general slope, the boundary of an offshore bank, or some isolated sink, in which locations they may locally rival the swarms encountered by Schmidt between Iceland and the Faroes.[71] As examples we may mention catches of several hundred off Cape Elizabeth on July 29, 1912; near Cape Sable on August 11, 1914; near Cashes Ledge on August 10, 1913, and again on September 1, 1915; in the sink off Gloucester on August 9, 1913; and on Platts Bank on August 7, 1912. Outside the 100-fathom contour, on the contrary, the records are usually based on occasional specimens only, and it is only in the northeastern part of the Gulf that they appear with any frequency over the deepest water (fig. 142). We have seldom taken young Sebastes in the western basin, though we have towed there frequently and at all seasons, and never in the deep southeastern trough of the Gulf nor in the eastern channel. All this suggests that the chief production of rosefish in the Gulf of Maine occurs at about 50 fathoms depth, which probably applies equally to the Bay of Fundy, where, according to Huntsman (1922a, p. 16), "the spawning individuals at least move out into deep water." However, the presence of larvæ no longer than 6.5 to 10 mm.—that is, new born—at every station where the species has been represented in our tow nettings by more than one or two examples, shows that some rosefish breed in the deepest parts of the Gulf, though it does not necessarily follow that the fish are on bottom there.

Apparently the rosefish never breeds in less than 20 to 30 fathoms west or south of Penobscot Bay. About Mount Desert, however, and further east along the coast of Maine, it may perhaps do so in shoal water. According to the European observations rosefish larvæ live close to the surface until they attain a length of 60 mm. (nearly 2½ inches), and, similarly, young larvæ (8 to 10 mm.) occasionally occur in great numbers on the surface in the Gulf of Maine, but most of our records are from 20 fathoms or deeper. The fact that we have never caught one larger than 21 mm. in our tow nets, whereas fry of 1½ to 3 inches are plentiful on bottom in the Bay of Fundy and have been trawled in abundance in deep water off southern New England (p. 310), suggests that they seek the ground at an earlier age in the Gulf of Maine than on the other side of the Atlantic.

The temperature in which rosefish breed in the Gulf of Maine is easily established with the spawning period so brief (p. 308) and with the adult fish summering below the zone most subject to seasonal warming. Thirty-seven to thirty-nine degrees may be set as the lower limit, for by the time breeding is well under way—say late in June or early July—there is no water colder than this in the Gulf. On the other hand the temperature at the 20-fathom level rises only to 46° or 48° by the end of August, except locally in regions of active vertical mixing, where it may

[71] Schmidt. Skrifter Udgivne of Kommissionen for Havundersøgelser, Nr. 1, 1904, p. 46.

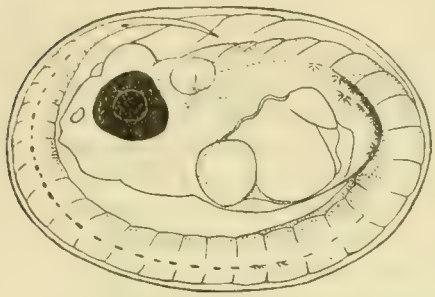

FIG. 143.—Egg from the oviduct of a female

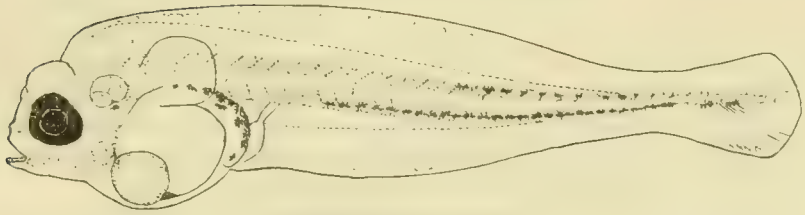

FIG. 144.—Larva, 6 millimeters

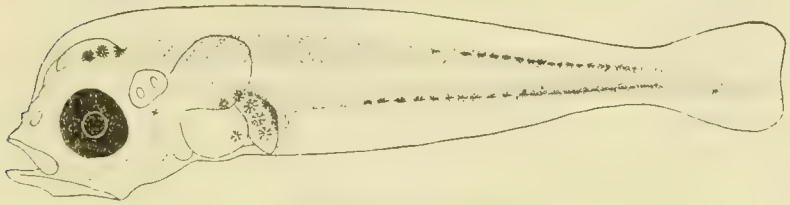

FIG. 145.—Larva, 9 millimeters

FIG. 146.—Larva, 12 millimeters

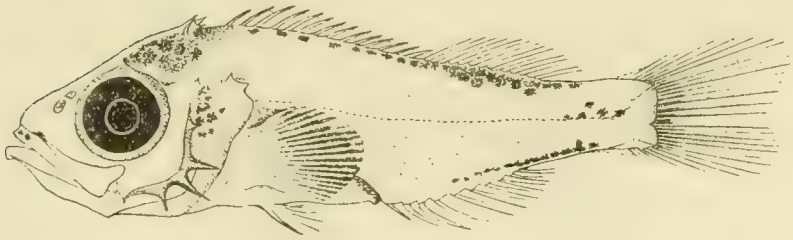

FIG. 147.—Fry, 20 millimeters

ROSEFISH (*Sebastes marinus*)

be a degree or two higher. Thus, practically the entire production of rosefish takes place in water colder than 47°, and apparently this upper temperature limit is a rather definite one, for there is some evidence that at breeding time the adult fish move out of Passamaquoddy Bay (which is then but a few degrees warmer) into deeper and cooler water in the open Bay of Fundy.

Turning to other seas we find rosefish breeding in 39° to 42° in the Gulf of St. Lawrence, in water at least as warm as 39° to 40° on the outer edge of the Grand Banks,[72] and in 37° to 39° or warmer off southern Newfoundland.[73] The hosts of rosefish fry to be found all over the Norwegian Sea are likewise produced in comparatively warm water (39° to 43°), as Hjort has emphasized. In fact it is doubtful whether Sebastes breeds at temperatures lower than 35° to 36° anywhere, for although it grows to a large size off west Greenland, Jensen states that females with large eggs and the early larval stages are both unknown there, but that the local stock is all produced in the Atlantic, reaching Greenlandic waters as immigrants with the current while still young. However, until the temperature at which it breeds is definitely established for the outer coast of Nova Scotia, where this would depend upon the precise depth at which the fish are living, the minimum temperature at which Sebastes can reproduce must remain in doubt.

The salinity in which rosefish breed is as definitely limited in one direction as is the temperature, if not in the other, for its young are for the most part produced in salinities upwards of 32 per mille.

The larvæ are about 6 mm. long at hatching (fig. 144), with the yolk mostly absorbed, the mouth already formed, and the first traces of the caudal rays already visible. At a length of 12 mm. (fig. 146) the dorsal and anal fin rays appear, the ventrals are visible, and the head spines are already prominent, while fry of 20 mm. (fig. 147) show most of the diagnostic characters of the adult except that head and eye are relatively larger. The red color is not developed until the little fishes are about to take to bottom, but all but the very youngest larvæ are easily recognizable by their large spiny heads, large eyes, short tapering bodies, very short digestive tract, and the presence of two rows of post anal pigment cells, a dorsal and a ventral. Nothing definite is known of the rate of growth of the older rosefish.

Commercial importance.—Although a very common fish and an excellent one on the table, as we ourselves can bear witness, as well as attractive in appearance, there is so little market for it that but a small part of the fish caught are brought in (p. 307), and what little was landed in 1919 (54,095 pounds) was valued at only two to three cents a pound. Every kind of fishing gear used in deep water catches rosefish.

[72] Murray and Hjort. The Depths of the Ocean, 1912, p. 110. London.

[73] Dannevig. Canadian Fisheries Expedition, 1914–15 (1919), Department of the Naval Service, p. 12.

117. **Black-bellied rosefish** (*Helicolenus maderensis* Goode and Bean)

Jordan and Evermann, 1896–1900, p. 1837.

Description.—This species resembles the common rosefish so closely in its general form and in the outline and arrangement of its fins that it would be apt to be mistaken for the latter were it not that the lower eight rays of the pectoral fins are free from the membrane for the outer one-half to one-third of their length, giving the fin an aspect very different from that of the rosefish. Furthermore, there are only 12 spines in the spiny portion of its dorsal fin instead of 14 to 15, as is the case in the rosefish, and only 5 soft anal rays (in addition to 3 stiff spines) instead of 7, while its caudal fin is relatively larger than that of the rosefish. A more important difference anatomically is that the present species has only 24 vertebræ, whereas the rosefish has 31.

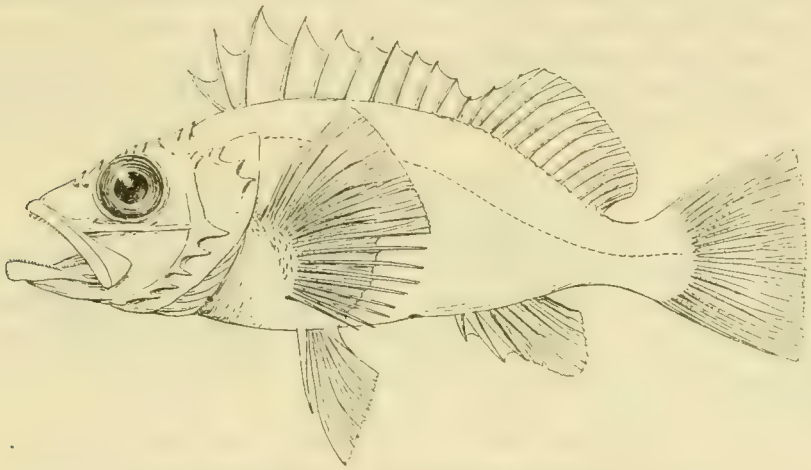

FIG. 148.—Black-bellied rosefish (*Helicolenus maderensis*). After Lowe

Color.—Described (we have not seen it) as pale to brilliant scarlet or flesh color, the gill cover with a vague leaden or dusky patch and the back and upper sides with five irregular cross bands of darker or brighter scarlet. All the fins are scarlet, the spiny part of the dorsal mottled with white, and the soft portion of the dorsal, the ventrals, and the anal edged with white. The lining of the belly is intense black, whence we have coined the English name "black-bellied rosefish."

Size.—About 15 inches in length.

General range.—This fish was first described from Madeira, but it has since been found at many localities off southern New England, off New York, and thence southward to Florida, in depths of 71 to 373 fathoms.

Occurrence in the Gulf of Maine.—This species is included here on the strength of three records—off Nantucket in 93 fathom , 208 fathoms, and 264 fathoms, respectively[74]—but since this is apparently near its northern limit on the American coast it is not likely that it ever enters further into the Gulf of Maine except as a stray.

[74] The precise localities are 40° N., 69° 19′ W.; 39° 51′ N., 69° 51′ W.; and 39° 56′ N., 69° 22′ W. Goode and Bean (1896) list all the American records.

THE SCULPINS. FAMILY COTTIDÆ

The several sculpins known from the Gulf of Maine are a homogeneous group characterized by large spiny heads, very wide gill openings, enormous mouths, slender tapering bodies, separate spiny and soft-rayed dorsal fins (except in rare species), large fanlike pectorals but small caudals, and ventrals reduced to three long rays. All of them, too, have a fashion of spreading the gill covers and flattening the head when taken in the hand. They likewise produce grunting sounds, and some sculpins have the power of inflating themselves with air when molested. The only other Gulf of Maine fishes that at all resemble them in general form are the sea robin (p. 345), toadfish (p. 357), and angler. However, the entire head of a "robin" is armed with bony plates, quite different from the soft-skinned head of a sculpin; in the toadfish the soft portion of the dorsal fin is many times as long as the spiny part, at most twice as long in a sculpin; and not only are the fins of the angler very small and weak as compared with the present family, but its lower jaw projects far beyond the upper and its mouth is full of very large pointed teeth, whereas in the sculpins the teeth are small and the jaws are of approximately equal length.

KEY TO GULF OF MAINE SCULPINS

1. There are two separate dorsal fins 2
   There is only one dorsal fin, the spiny and soft parts being united. Deep-sea sculpin, p. 329
2. The first dorsal fin is deeply notched between the spines; the lower jaw and the top of the head are adorned with fleshy tags ..... Sea raven, p. 330
   The first dorsal is not deeply notched between the spines; no fleshy tags about the head 3
3. The long spine on each cheek is branched at the tip ..... Staghorn sculpin, p. 328
   These spines are simple, not branched 4
4. The anal fin is long (25 rays); there is a series of bony plates along the sides ..... Mailed sculpin, p. 316
   The anal fin is short (14 rays or less); there are no bony plates on the sides 5
5. The long spine on the cheek is hooked upward ..... Hook-eared sculpin, p. 314
   This spine is straight, not hooked 6
6. The longest (uppermost) cheek spine is four times as long as the one below it, reaching back to the margin of the gill cover; all head spines are very sharp. Longhorn sculpin, p. 325
   The uppermost cheek spine is not more than twice as long as the one below it, nor reaching more than about halfway to the margin of the gill cover; head spines are blunter 7
7. The first dorsal fin is decidedly higher than the second; small fish (not over 8 inches long) ..... Grubby, p. 318
   First and second dorsal fins are about equal in height ..... Shorthorn sculpin, p. 320

118. **Hook-eared sculpin** (*Artediellus atlanticus* Jordan and Evermann)

ARCTIC SCULPIN

Jordan and Evermann, 1896–1900, p. 1906.

Description.—The most distinctive feature of this species among local sculpins is the long hooklike spine on the cheek, pointing backward and upward, plainly shown in the illustration (fig. 149). There is also a short backward-pointing spine covered by a flap of skin at the upper corner of the gill cover, two short spines on

the top of the nose between the two pairs of nostrils, and a pair of blunt knobs above the eyes. Head, mouth, and tapering body are of the usual sculpin form. The skin is smooth and naked. The spiny dorsal is short (7 to 9 spines) and rounded in outline, the soft dorsal is more than twice as long (13 rays), and the anal (11 rays) is slightly shorter than the soft dorsal, which it resembles in outline and under which it stands. The ventrals each consist of three long rays reaching back to the vent; the pectorals, wide at the base and rounded in outline, reach beyond the beginning of the soft dorsal when laid back, and the caudal fin is narrower than in the commoner Gulf of Maine sculpins. The jaws and the roof of the mouth are armed with several series of small bristlelike teeth.

Color.—Described (after preservation) as reddish brown above with creamy sides and dirty white belly, the sides showing vague crossbars of the same color as the back. There is a dark blotch at the base of the caudal fin, and the head is mottled with brown. The spiny dorsal is blackish with two or three irregular white cross streaks, while the soft second dorsal shows six or seven dark crossbands; the pectoral and caudal fins are marked with two or three and the anal with four irregular dark bars.

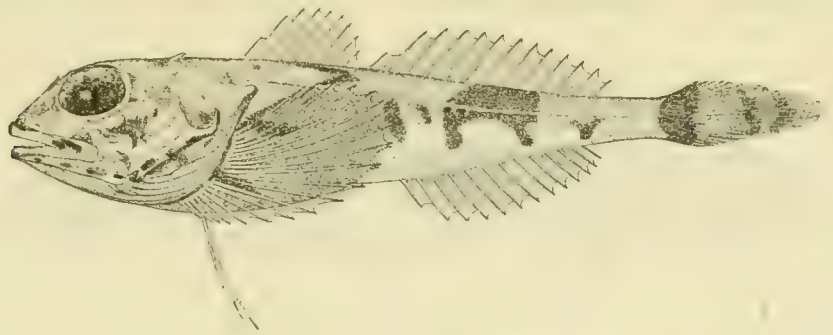

FIG. 149.—Hook-eared sculpin (*Artediellus atlanticus*)

Size.—Only about 4 inches long—one of the smallest of sculpins. The largest of the few trawled by the *Grampus* (p. 315) was only about 2½ inches (63 mm.) long.

General range.—This is a cold-water species known from Labrador to Cape Cod. It is replaced in the littoral waters of arctic Europe, Siberia, and Greenland by a form (*Artediellus uncinatus*) so closely related that we suspect a critical examination of the two would lead to their union.

Occurrence in the Gulf of Maine.—In the Gulf this species is confined to depths of about 40 fathoms or deeper. Evidently it is fairly common in the deeper parts of Massachusetts Bay, for it was dredged there in abundance in 40 to 90 fathoms on several occasions many years ago. Other definite records for it in the inner parts of the Gulf are as follows: Two were trawled by the *Grampus* off Cape Elizabeth in 40 fathoms and four off Monhegan Island in 60 fathoms in July, 1912. It has been reported "off Cape Cod" in 110 fathoms; the *Albatross* trawled it in the southeast basin of the Gulf (42° 17′ N. 66° 37′ W., 150 fathoms) and at the offshore entrance to the eastern channel (42° 03′ N. 65° 49′ W., 131 fathoms); also on the

slopes of Georges Bank (40° 03′ N. 68° 07′ W.), as well as at various localities thence northward and eastward to the Grand Banks in 40 fathoms and deeper. When the bottom of the Gulf is more systematically explored this Arctic sculpin will probably be found very generally distributed there at 50 to 75 fathoms on sandy or stony bottom, but we doubt if it haunts the soft sticky mud that floors the greater part of the deep basin. Presumably it is resident in small numbers, sculpins not being migratory, but nothing whatever is known of its life or breeding habits.

119. **Mailed sculpin** (*Triglops ommatistius* Gilbert)

Jordan and Evermann, 1896–1900 (*Triglops pingelli*), p. 1923.
Gilbert, Proceedings, U. S. National Museum, Vol. 44, 1913, p. 465.

Description.—The most diagnostic feature of this sculpin, apart from its very long anal fin (p. 314), is the presence of a row of about 45 broad plate-like scales along its lateral line, with smaller spiny scales below the dorsal fins, while the skin of the lower sides is gathered in obliquely transverse folds. The body, too, is more tapering than in our other sculpins, while the caudal peduncle is more slender and the tail is smaller. Furthermore, the head is smaller and smoother than in any

FIG. 150.—Mailed sculpin (*Triglops ommatistius*)

of the sculpins common to the Gulf of Maine, with short spines and many prickles. The first dorsal fin (11 spines) originates over the base of the pectoral and is higher but only about half as long as the second dorsal (21 to 22 rays). The anal fin is similar to the latter in form and stands below it, but is slightly shorter (20 to 21 rays). The ventrals (3 rays as is the rule among sculpins) reach about as far back as the end of the first dorsal, while the pectorals (17 rays) are of the usual fanlike outline. In the males there is a very large and noticeable anal papilla, which is lacking in females.

Color.—Described as olivaceous above, the back with four dark crossbars running down the sides to the lateral line, and with a series of blackish blotches below the latter. In males there is a large roundish black spot margined with silvery white on the margin of the first dorsal fin behind its middle, and the second dorsal is marked with wide oblique or nearly horizontal bars. Females lack the eye spot on the first dorsal, and with them the barring of the second dorsal is in the form of narrow lines of dots. There are no markings on the other fins. The breast and belly are silvery white.

Size.—This is a small species, probably growing to a maximum length of about 8 inches, this being the largest size recorded for its European representative.[75]

General range.—It is impossible as yet to state the geographic limits of this species. Sculpins of this general type are circumpolar, ranging south to Cape Cod along the American coast and to the Baltic on the European side of the Atlantic in rather deep water. They show a tendency to split up into local races, however, the constancy of which is yet to be tested by a study of large series. Newfoundland specimens, for example, differ sufficiently from typical *Triglops ommatistius* in the arrangement and number of folds of skin along the sides for Gilbert to have dignified them with a separate name (as the subspecies *terrænovæ*); and both these American forms are distinguished from the east Greenland and European mailed sculpins by the presence of the eyespot on the first dorsal fin (which the latter lack), and by slightly fewer fin rays. We do not feel convinced, however, that all these forms, together with the Bering Sea form (*Triglops beanii*), will not finally prove to be local varieties of a single wide-ranging species.

Occurrence in the Gulf of Maine.—This cold-water fish must be rare in the Gulf, for the only specimens so far definitely recorded from there are from the neighborhood of St. Andrews in the Bay of Fundy, taken in 15 fathoms in April and July, 1919 (reported by Huntsman); a few from Massachusetts Bay and from off Race Point, Cape Cod (in the collection of the Boston Society of Natural History); 11 others now in the United States National Museum from Gloucester, Cape Cod, and Georges Bank; and two which we ourselves trawled on the *Grampus* in July, 1912, one of them off Gloucester and the other off Boston Harbor, at 33 and 27 fathoms, respectively. The fact that Gilbert found differences between the Gulf of Maine and Newfoundland specimens, and others from Chebucto Head (Nova Scotia) and from Georges Bank intermediate between them, suggests that the mailed sculpin is a permanent resident of the inner parts of the Gulf, rather than that it appears there only as an occasional stray past Cape Sable from the east and north.

Habits.—Little is known of its habits beyond the bare fact that it is a bottom fish like other sculpins. If it breeds at all this side of Cape Sable it probably spawns in midsummer, Cox[76] having reported a ripe female at Cape Breton in July. The eggs of the latter were pinkish, 2 mm. in diameter, with many oil globules. Presumably the eggs sink like those of other sculpins. The European mailed sculpin is known to eat worms and various small crustaceans and probably the diet of the American form is the same.

[75] Collett. Den Norske Nordhaus-Expedition, 1876–78, Bind 3, Zoologi, Fiske, 1880, p. 38. Christiania.
[76] Contributions to Canadian Biology, 1918–1920 (1921), p. 111. Ottawa.

120. Little sculpin (*Myoxocephalus æneus* Mitchill)

Grubby

Jordan and Evermann, 1896–1900, p. 1972.

Description.—The most diagnostic features of the grubby, as compared with others of its tribe, are a high first dorsal fin combined with small size and short head spines. It is of the typical sculpin form (p. 314), though proportionately a stouter fish than either the short or long-spined species—that is, about one-fourth as deep as long—with smooth skin but showing the head ridges and spines typical of its genus. Most noticeable of these are a ridge with three spines running along the top of the head over each eye, a pair of spines above the nostrils, and six (all short) on each side of the face between snout and gill opening. None of the cheek spines are long (p. 314). The spiny dorsal (9 spines), originating slightly in front of the upper corner of the gill opening, is decidedly higher but shorter than the second (13 to 14 soft rays), and the two fins are so close together that there is no free space between them. The anal (10 to 11 rays) is slightly shorter than the

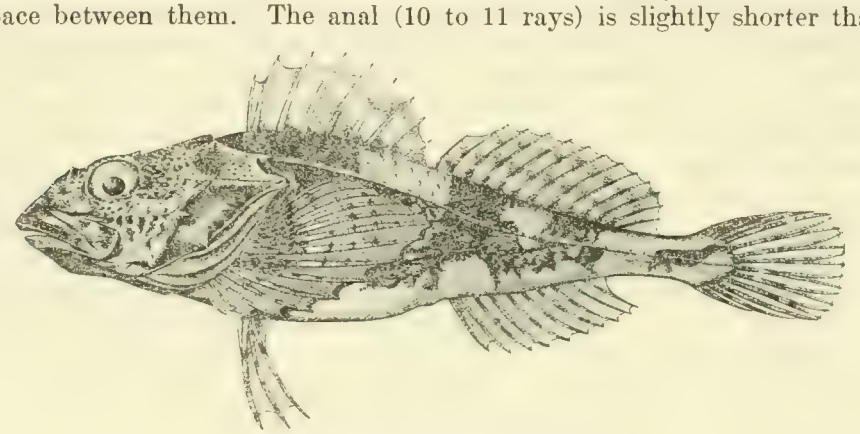

Fig. 151.—Little sculpin (*Myoxocephalus æneus*)

second dorsal, under which it stands. The pectoral is of the fanlike outline characteristic of this family, while the ventrals have the usual three rays. There is no slit or pore behind the last gill (usually there is such a slit or pore in the shorthorn sculpin, p. 320).

Color.—Grubbies, like other sculpins, vary in color according to the bottom on which they lie. All that we have seen, however (this confirms the published descriptions), have been light to dark gray or greenish-gray above, with darker shadings or irregular barrings particularly evident on the sides and fins. The sides of the head are usually mottled light and dark; the belly pale gray or white.

Size.—This is the smallest of our common sculpins, being seldom more than 5 and perhaps never more than 8 inches long.

General range.—North American coastal waters, Gulf of St. Lawrence to New Jersey.[77]

[77] Maine has sometimes been given as its northern limit, but Doctor Huntsman writes us that in 1915 he obtained it in tide pools at Souris, Prince Edward Island, and Cox (Contributions to Canadian Biology, 1918–1920 (1921), p. 111) describes it as the commonest sculpin at the Magdalen Islands.

Occurrence in the Gulf of Maine.—Probably this little sculpin is to be found in suitable localities all around the shores of the Gulf of Maine, for it is common along both shores of the Bay of Fundy on the one hand and has been obtained at various localities in the Massachusetts Bay region—e. g., Cape Ann, Gloucester, Salem, Cohasset, Provincetown—on the other. It seems decidedly local in its distribution, however, for the only locality where it has been definitely reported on the intervening coast line is Casco Bay, where it is not uncommon, nor have we ourselves caught it in any of the harbors of Maine where we have fished. Being common in St. Mary Bay (Huntsman, 1922a), it is to be expected along the western coast of Nova Scotia, but it is far outnumbered in the Gulf of Maine by the two larger sculpins to be mentioned next.

Habits.—Practically nothing is known of the life of the grubby north of Cape Cod except that it associates with other sculpins, with the young of which it is usually confounded. On the southern shores of New England, where it is not only more nearly universal but far more plentiful than anywhere north of Cape Cod, it is found from close to tide mark down to 15 fathoms or so, and it seems that it is similarly restricted to comparatively shoal water in the Gulf of Maine, for we have found no record of it, nor have we seen it dredged or trawled, in deep water. In the Gulf of St. Lawrence, however, Cox found it in the stomachs of cod taken in 60 to 70 fathoms. It is found on all sorts of bottom but most abundantly among eelgrass, and it is resident the year round. It is the only sculpin that summers in shoal water at Woods Hole, and it has been recorded far up Narragansett Bay in very shoal water in midsummer, and is to be found in Gravesend Bay at the mouth of New York Harbor throughout the year. In the Gulf of St. Lawrence (e. g., at the Magdalen Islands) it is found in estuaries just as it is in the southern part of its range, as well as outside, but in the Gulf of Maine it seems more restricted to the open coast, for Huntsman found it rare as far up Passamaquoddy Bay as St. Andrews, though common at its mouth, and more plentiful in St. Mary Bay and in Annapolis Basin than in the Basin of Minas on the Scotian side of the Bay of Fundy. Nor have we seen it in salt creeks about Massachusetts Bay.

The known distribution of the grubby in summer proves that it is certainly at home in water as warm as 69° and perhaps a degree or two warmer. On the other hand, in winter it necessarily survives temperatures as low as 32°, if not lower, both in the Gulf of St. Lawrence and about Woods Hole. Its presence in such estuarine situations as the inner parts of Narragansett Bay on the one hand and off open coasts on the other prove it resistant to a wide range of salinity, but so far as we can learn it never runs up into appreciably brackish water, and certainly the great majority of the species keeps to waters more saline than 31 per mille.

The spawning season of the grubby lasts all winter off southern New England and until June in the Gulf of St. Lawrence, for Cox reports a ripe female on the 18th of that month, at Amherst Island (Magdalen group). The eggs, which are described as of a beautiful green color and 1 mm. in diameter, sink like those of other sculpins and stick to seaweeds or to any object they chance to rest upon, including the nets in which the grubbies are caught. Young sculpins (this species among them) are caught in the tow net at Woods Hole from January to May.

Probably the grubby breeds throughout its geographic range, certainly as far north as the southern part of the Gulf of St. Lawrence, and the Bay of Fundy is the site of successful reproduction, for Huntsman found grubbies of all sizes there.

Food.—This sculpin is omnivorous like its relatives, feeding on all sorts of small animals which it finds on the bottom, such as annelids, prawns, shrimps, gastropods, nudibranchs, ascidians, crabs, copepods, and on small fish, including alewives, cunners, eels, mummichogs, launce, silversides, sticklebacks, and tomcod.[78] It also scavenges any kind of animal refuse.

Commercial importance.—Too small to be worth catching for lobster bait, and never eaten, the grubby is of no commercial value, but wherever it is common it is something of a nuisance to anglers fishing for flounders and cunners for it bites as greedily at any bait as do its larger relatives.

121. **Shorthorn sculpin** (*Myoxocephalus scorpius* Linnæus)

DADDY SCULPIN; BLACK SCULPIN; GREENLAND SCULPIN

Jordan and Evermann (*M. scorpius* and *M. grænlandicus*), 1896–1900, p. 1974.

Description.—The most precise character by which to distinguish the young of this species from the grubby (no one could confuse the adults) is that there is a pore, small but evident, behind the last gill. Readier field marks are that its spiny dorsal is no higher than the soft dorsal (p. 314), and that its anal fin originates farther back in relation to the latter and is usually longer (at least 13 rays in the shorthorn and only 10 to 11 in the grubby). Furthermore, there are usually 16 or 17 soft dorsal rays, while in the grubby there are only 13 or 14. The number of fin rays varies widely among European representatives of the shorthorn sculpin [79] and the same may be expected with American fish.

The most obvious difference between the shorthorn and the longhorn sculpins is that the upper cheek spine of the former is less than twice as long as the one below it and does not reach much more than halfway to the edge of the gill cover. Furthermore, all its spines are usually blunt, while those of the longhorn are very sharp (p. 325). The general arrangement of head spines and ridges is the same in the two, however, there being a longitudinal ridge with three knobs or spines running along each side of the crown above the eye, and about 6 (sometimes 5 or 7) short triangular spines on each side of the face between snout and gill opening. There is also a short but sharp spine at the upper corner of the gill cover pointing backward and lying on a skin flap, besides two thornlike spines on each shoulder close behind the upper angle of the gill cover.

The first dorsal fin has 9 to 11 spines, the caudal is small and slightly rounded, the anal is considerably shorter than the second dorsal and originates under its fourth or fifth ray, and the pectorals are fanlike. There are two series of prickly plate-like scales along each side of the body, one above, the other below the lateral line, and this species resembles other sculpins in its large head, wide mouth, and tapering body (p. 314).

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[78] This list of fish fry is from Vinal Edwards's notes at Woods Hole.

[79] Smitt. Scandinavian Fishes, 1892, p. 180.

FIG. 152.—Adult

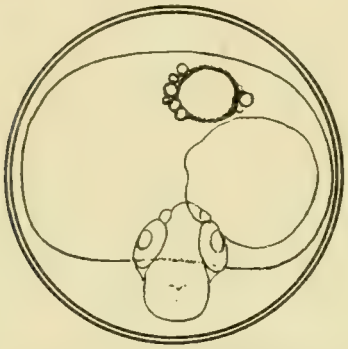

FIG. 153.—Egg. After Ehrenbaum

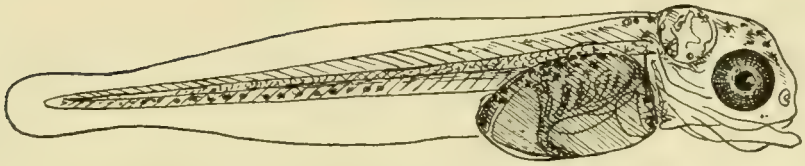

FIG. 154.—Larva (European), 8.2 millimeters. After Ehrenbaum

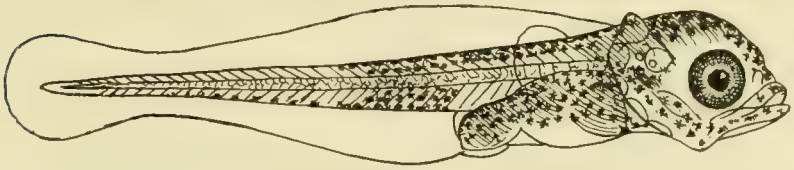

FIG. 155.—Larva, 10 millimeters. After Ehrenbaum

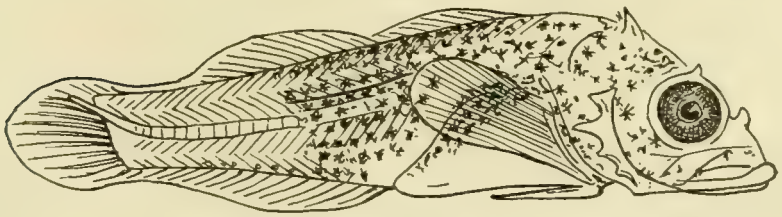

FIG. 156.—Fry, 18 millimeters. After Ehrenbaum

SHORTHORN SCULPIN (*Myozocephalus scorpius*)

Males and females differ in appearance, the former being the more slender and with higher fins. Each of the scales along the lateral line bears three or more prickles in males, but only one or two at the most in females, while some of the latter have no scales. Furthermore the inner edges of the rays of the pectoral and ventral fins are armed with teeth or prickles in the male but not in the female.

Color.—The basic hue of the upper parts is usually some shade of brown, ranging from a warm reddish tint to almost black, with the top sides of the head marked with pale blotches and the back and sides with broad dark bars. The lower sides are more or less spotted with yellow. The belly is yellowish in females and reddish orange with large round white spots in males, this being a good field mark for distinguishing the sexes. The dorsal fins are dark and pale mottled, the second often with 3 or 4 definite crossbars, and the caudal with various dark mottlings. The rays of the pectoral and anal fins are yellow with 2 or 3 irregular dark crossbars. Males are more brightly colored than females in the breeding season, their red and yellow tints becoming very brilliant, with the intensification of the red or coppery ground color of the belly bringing out the white spots more clearly than at other seasons.

Size.—This is the largest Gulf of Maine sculpin, growing to a length of about 3 feet, but the average run of the adults taken there is only about 8 to 14 inches. This species increases in size from south to north, Greenland fish averaging much larger than those taken off New England or the Maritime Provinces.[80]

General range.—One or another race of this variable fish is known from Great Britain northward all along the coasts of Europe, in Arctic seas generally, including Spitzbergen, Nova Zembla, north Siberia, west Greenland, and northern Labrador, and southward along the American coast to New York.

Occurrence in the Gulf of Maine.—This is one of the most familiar shore fishes, common all around the whole coast line of the Gulf of Maine, though neither as abundant nor as universal as the longhorn sculpin (p. 325). Perhaps 50 fathoms, from which depth Huntsman records one near Campobello Island at the mouth of the Bay of Fundy, may be set as its lower depth limit. It is seldom caught on cod or hake trawls deeper than 15 to 20 fathoms, and although a day's codfishing on any of the shoaler ledges, in say 8 to 10 fathoms, is likely to yield an occasional "shorthorn" among other fish, the great majority live in depths of less than 5 or 6 fathoms. Although more strictly confined to shoal water than is the longhorn sculpin (p. 326), it is less often seen close to tide mark, usually being in at least a fathom of water. It does not run as far up the estuaries and never into brackish water. This sculpin has not been positively recorded from Georges or Browns Banks. Sculpins of some sort, it is true, are so common on the former that the otter trawls often catch from 20 to 100 per set, and equally so on Browns Bank, but fishermen lump this and the next species together, and the fact that the few that have been positively identified on the banks have all proved to be longhorns

[80] Most American ichthyologists recognize two subspecies of this fish—the true "shorthorn" (*scorpius*) and the "Greenland sculpin" (*grœnlandicus*)—and with the prevailing tendency to call American and European fish by different names it is as the latter that our local sculpin has usually been recorded. The differences between the two (size, relative breadth of the top of the head, and length of the spines of the dorsal fin) are so very slight, however, and all of them have proven so variable, that we follow Huntsman (1922a) in uniting the two, the more willingly since both forms have been found on each side of the Atlantic.

(p. 326), with the general predilection of the shorthorn for water shoaler than these offshore grounds, makes it doubtful whether it is to be found there in any numbers.

Habits.—Bays and the vicinity of ledges that rise from comparatively smooth bottom in shoal water are the chief habitat of the shorthorn sculpin. It is found indifferently on mud, sand, or pebbles, on bare bottom or among weeds. Many are caught off piers and along our rocky shores by cunner fishermen In Scandinavian waters this fish is said to vary widely in abundance from year to year, years of plenty alternating with longer periods of scarcity, but this does not seem to be the case to any noticeable extent in the Gulf of Maine where it is always common.

Like its commoner relative (p. 325) it is a sluggish fish, often to be seen lying motionless, and as a rule it hugs the bottom so closely that it is hard, even by dangling a bait over it, to tempt one to rise as much as a few feet. Nor does it ever come to the surface voluntarily unless, when caught in some tide pool, the surface drops to the sculpin on the ebbing tide. Sculpins usually swim slowly with undulating motion, spreading the great pectorals like bat's wings. They move only a little way when disturbed, but on occasion they can dart ahead with folded "wings." They are among the most voracious of fishes, feeding chiefly on crustaceans, particularly crabs, of which they are often full, and on shrimps, sea urchins, worms, the fry of various other fish, and rarely on shellfish. They are eager scavengers of any kind of refuse, congregating about fish wharves, lobster cars, etc., to feast on the débris. Like all species of sculpins they bite on any bait, and so greedily that time and again I have caught one, thrown it back, and seen it bite again almost as soon as a fresh bait reached bottom. The shorthorn has been described as hiding in dark crevices or among weeds by day, to emerge at night. This, however, has not been our experience, nor did Gill (1905, p. 352) find it so at Grand Manan. This fish, like the longhorn sculpin, grunts or gurgles when drawn out of the water, particularly when handled, and it is also known to grunt in the water.

The shorthorn sculpin is resident the year round off the open coasts of the Gulf of Maine, and may be caught in winter as well as in summer. In the Bay of Fundy, where it is very common, it is the only fish remaining near shore during the coldest part of the year, and it has been described as most plentiful along the shores of Massachusetts Bay in winter, as it certainly is south of Cape Cod. This does not apply to shallow bays with broad expanses of flat left bare at every tide, however, such as Duxbury Harbor where sculpins are plentiful in spring and autumn but which they so completely desert both in the coldest part of the winter and during the heat of midsummer that local lobster fishermen are forced to turn to other sources for bait. Probably the explanation is that like many other fishes they avoid both very high and very low temperatures, and that during the breeding season, which falls in winter, practically the whole stock of adults gathers on grounds that for some reason are especially suitable for spawning.

Breeding habits.—This is the only one of our local sculpins whose breeding has been followed, and even for this one we must turn to European sources, little attention having been paid to this phase of its life by American ichthyologists.[81]

[81] Gill (1905, p. 35) gives a summary of its life history.

The spawning season, both about Woods Hole and in north European waters, is from November until February, with the chief egg production in December, and no doubt this applies equally to the Gulf of Maine. At this season the adult sculpins have been described as gathering in schools on sandy or weedy bottom, with the females greatly outnumbering the males. Discussion has centered about the manner of fertilization of the eggs, whether invariably external or sometimes internal, it being generally agreed that they are fertilized externally as a rule but that in parts of the Baltic they may be fertilized within the body of the mother. In either case they are discharged in clumps, sink [82] and stick together in irregular spongy masses through which the water circulates, and which retain considerable moisture even if left bare by the ebbing tide, as often happens. These egg masses are deposited on sandy bottom, in pools in the rocks, among seaweeds, or in any crevice or hollow—a tin can, for instance, or an old shoe. Sometimes the male makes a nest of seaweed and pebbles, while he has been described as sometimes clasping the egg mass with his pectoral and ventral fins and has been photographed, too, while so employed.[83]

The eggs are of varying shades of red or yellow, 1.5 to 2 mm. in diameter. Incubation is so slow (occupying 4 to 12 weeks, according to temperature) that egg masses with advanced embryos have often been found as late in the spring as April or even May. Newly hatched larvæ are about 7 to 8 mm. in length. In a month they are 10 mm. long and the yolk sac has been absorbed. The young larvæ come to the surface, where quantities of them have been taken in tow nets in British waters in March, April, and May. By May and June some have grown to a length of 22 to 25 mm., and at about this size, or soon after, they abandon their pelagic life for the bottom. By July they may be 38 mm. long and show all the diagnostic characters of the adult.[84] This time-table, compiled from European sources, probably applies equally to the Gulf of Maine, for larvæ are found as early as February in the Bay of Fundy and thereafter throughout the spring.[85] The subsequent rate of growth is not definitely known. Probably, however, this sculpin is 2 or 3 inches long by the end of its first year and 4 to 5 inches by the end of its second year, when a few are mature; but most of them, it seems, do not mature until at least 6 inches long or 3 years old.

Commercial importance.—Although this is an edible fish, and by account a good one, its repulsive appearance and scavenging habits will probably close our markets to it as long as better fish are plentiful. Nevertheless, it is of some commercial importance, being one of the best baits for lobster pots, for which purpose great numbers are speared locally in Massachusetts in spring and caught all along the coast of the Gulf on hook and line.

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[82] Pelagic eggs taken in the tow net (Agassiz, 1882, pl. 3) belonged to some other fish.

[83] Ehrenbaum. Wissenschaftliche Meeresuntersuchungen, Helgoland, Neue Folge, Band 6, 1904, Taf. VIII. Kiel und Leipzig.

[84] McIntosh and Masterman. The Life-Histories of British Marine Food-Fishes, 1897, p. 129. London.

[85] Huntsman, 1922a, p. 16.

122. Longhorn sculpin (*Myoxocephalus octodecimspinosus* Mitchill)

GRAY SCULPIN; HACKLEHEAD; TOADFISH

Jordan and Evermann, 1896–1900, p. 1976.

Description.—This fish resembles the shorthorn sculpin so closely that the description may be confined to the points of difference between the two. Chief of these is the great length of the uppermost cheek spines, which usually are about four times as long as the spine just below and reach at least as far back as the edge of the gill cover. This serves equally to distinguish the young from the grubby, which is short-horned. All the head spines, too, are so sharp that one must be cautious in grasping one of these fish for it turns its spines rigidly outward by spreading its gill covers. Furthermore the long horns are naked at the tip. The number and arrangement of the head spines is the same as in the shorthorn sculpin (p. 320), hence need not be described, and there are two thorns on each shoulder and a larger one just above the origin of the pectoral fin. The first dorsal fin is higher than the second (in the shorthorn sculpin these two fins are about

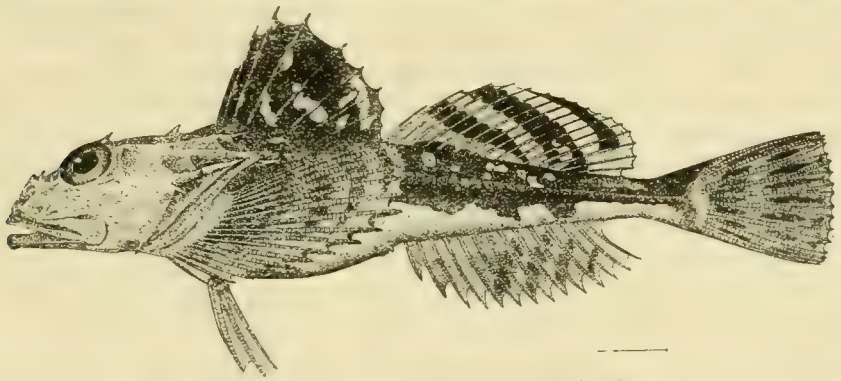

FIG. 157.—Longhorn sculpin (*Myoxocephalus octodecimspinosus*)

equally high), of rather different outline from that of the shorthorn (compare fig. 157 with fig. 152), and proportionately shorter though with about the same number of spines (9). The anal fin originates under the second or third ray of the second dorsal instead of under the fifth ray, though these two fins have the same number of rays (15 to 16 dorsal and about 14 anal) in the two fish, and the pectorals are of the same fanlike form. The lateral line of the longhorn sculpin is marked by a series of smooth cartilaginous plates instead of by the prickly scales of the shorthorn, a difference obvious to the touch, and its body is more slender (about five and one-half times as long as deep) and its head flatter.

Color.—The longhorn, like other sculpins, varies in color with its surroundings. The ground tint of the back and sides ranges from dark olive to pale greenish-yellow, greenish-brown, or pale mouse gray, but is never red or black as the shorthorn so often is. As a rule there are four irregular obscure dark crossbars, but these are often broken up into blotches and may be indistinct. The coarseness of pattern often corresponds to that of the bottom, as does the degree of contrast between pale and dark. On mud and sand bottom this sculpin is often nearly plain, but when lying on pebbles with white corallines its back is often nearly

white with dark gray blotches, rendering it almost invisible. The first dorsal fin is pale sooty with pale and dark mottlings or spots, the second dorsal is paler olive with three irregular oblique dark crossbands, and the caudal is pale gray and the pectorals yellowish, both with 4 to 6 rather narrow but distinct dark crossbands. The anal is pale yellowish with dark mottlings. There is often an obscure yellowish band along the lower sides marking the transition from the dark upper parts to the pure white belly.

Size.—This is a smaller fish than the shorthorn sculpin, growing to a maximum length of about 18 inches but rarely more than 10 to 14 inches long.

General range.—East coast of North America from Labrador to Virginia.

Occurrence in the Gulf of Maine.—This is the commonest local sculpin, to be caught anywhere and everywhere along the entire coast line of the Gulf of Maine. We dare venture there is not a bay, harbor, estuary, or a fishing station from Cape Sable to Cape Cod where it is not to be found. Not only is it more plentiful in most places than is its short-horned relative, but it occupies a wider depth zone, being very abundant on the one hand in many shoal harbors, where it comes up on the flats at high tide to leave them at low, while on the other it is caught in considerable numbers down to 50 fathoms or so. We have ourselves trawled it at 27 to 33 fathoms in Massachusetts Bay and at 50 fathoms off Cape Elizabeth, but since this is about its lowest limit (it has not been reported from the deep basin) its range in the inner parts of the Gulf is restricted to a narrow peripheral zone. It also occurs on Georges Bank, and while the composition of the sculpin population of that region is yet to be determined, the fact that this was the only sculpin (except the sea raven, which it outnumbered) that Welsh saw taken there on an otter-trawling trip in June, 1912, is presumptive evidence that it is the commonest member of its tribe on the bank. It is fair to assume that this applies equally to Browns Bank, where fishermen report sculpins of one sort or another as not uncommon.

Habits and food.—Plentiful and omnipresent though this fish is, little attention has been paid to its life history. Everyone who has fished along the shores of the Gulf is perforce more or less familiar with it, for it is a nuisance to cunner and flounder fishermen, and often puzzles a "greenhorn" to unhook it when it spreads all its needle-sharp spines and erects its spiny dorsal. It grunts when pulled out of the water and bites any bait.

No doubt it is as omnivorous as the shorthorn. Specimens examined by Vinal Edwards at Woods Hole had fed chiefly on shrimp, crabs, and mussels, also on hydroids, annelids, amphipods, sundry mollusks, ascidians, squids, and a considerable list of fish fry, including alewives, cunners, eels, mummichogs, herring, mackerel, menhaden, puffers, launce, scup, silversides, smelts, tomcod, silver hake, and other sculpins.

This sculpin is as useful a scavenger as the shorthorn and equally voracious, gathering wherever there is carrion to be had about wharves, sardine factories, and particularly under lobster cars, and always keeping to the bottom. Along most of our coast line it is resident throughout the year in waters of moderate depth, but it carries out more or less definite inshore and offshore journeys within

narrow limits. Thus in winter it deserts the shoalest bays where the flats are laid bare at low tide (Duxbury Bay, for example), no doubt to avoid the extreme cold, reappearing there in March, moving out again in midsummer when the water on the flats is warmest, to work back to the shallows once more in September or October. In the estuaries of the Bay of Fundy, however, where the summer temperature of the shoal water is lower than in similar locations in other parts of the Gulf, longhorn sculpins are most plentiful during the warm months and almost all of them move out into the open bay to pass the winter. Along the southern shores of New England, where the coastal waters are much warmer in summer than in most parts of the Gulf of Maine, this sculpin is abundant in autumn and winter, but rarely taken in very shoal water in summer.

These migrations are probably induced by temperature and they are sufficient evidence that this species avoids both the warmest and coldest water—that is, temperatures higher than 55° to 60° and lower than 35°. However, even freezing temperatures are not fatal to it, for we find no evidence that sculpins are ever killed by cold when caught on the flats in severe freezes, a fate that occasionally overtakes cunners and tautog.

Breeding habits.—All that is known of the breeding habits of this sculpin is that it spawns in November and December about Woods Hole, its eggs sinking together in clumps like those of the shorthorn sculpin, and often being thrown up on the beach in masses. Presumably the spawning season is the same in the Gulf of Maine, but whether it gathers in particular localities or at any precise depth to spawn or does so indifferently on all kinds of bottom is yet to be learned. The presence of sculpins of all sizes, from very young fry to adult, proves that it breeds generally along the coasts of Massachusetts Bay and Maine, probably along western Nova Scotia as well; but in the Bay of Fundy it seems restricted as a breeder to the Scotian side, the absence of young on the New Brunswick shore proving that the half-grown and adult fish that are so plentiful there are immigrants either from across the bay or from the Gulf outside.

The larval stages have not been described previously; hence it was interesting to tow four young sculpins in April, 1920 (three on the eastern part of Georges Bank and one in the Eastern Channel), which probably belonged to this species because of their long cheek spines. The smallest of these larvæ was 13 mm. long, showing the first traces of the dorsal and anal fin rays, and the largest was 21 mm. long. The larvæ are more slender than corresponding stages of the shorthorn sculpin (p. 321), and differ from them in the outline of the dorsal fin, for in the longhorns (if our identification be correct) it is continuous from end to end, only the largest of them showing a shallow notch to separate its spiny from its soft portion, whereas in the shorthorn the two sections are separate from the time the fin first takes finite form. Nothing definite is known of the rate of growth of this fish nor of the age at which it matures.

Commercial importance.—The only commercial value of this sculpin is as bait for lobster pots, for which it is used in great numbers, being speared in some localities and caught on hook and line in others. It is a fairly good fish on the table and a few are eaten by the foreign-born population, but there is no market for them.

123. **Staghorn sculpin** (*Gymnocanthus tricuspis* Reinhardt)

Jordan and Evermann, 1896–1900, p. 2008.

Description.—This sculpin is easily distinguishable from its more common relatives by the fact that the uppermost of the three cheek spines is broad, flat, and 3-branched at the tip instead of cylindrical and single pointed; also by the fact that the anal fin (16 to 18 rays) originates well in front of the second dorsal instead of behind it, and that its two dorsals are separated by a distinct space instead of being practically continuous at the bottom of the notch that demarks them. Furthermore the spines characteristic of the top of the head and shoulders of the other sculpins on our coast are either lacking in the staghorn or are very short, and the corner of its gill cover is rounded instead of sharp pointed. Diagnostic, also, if less obvious, is the fact that the top of the head is more or less prickly or warty. The length of the ventrals has been stated variously by different authors. According to Smitt [86] they do not reach back to the vent, but H. R. Storer [87] represents them and Jordan and Evermann describe them as much longer, extending to the anal fin.[88] The first dorsal is of 11 or 12 spines; the second of 15 to 17 rays. The caudal and pectoral fins and the general form of the fish are of the usual "sculpin" type.

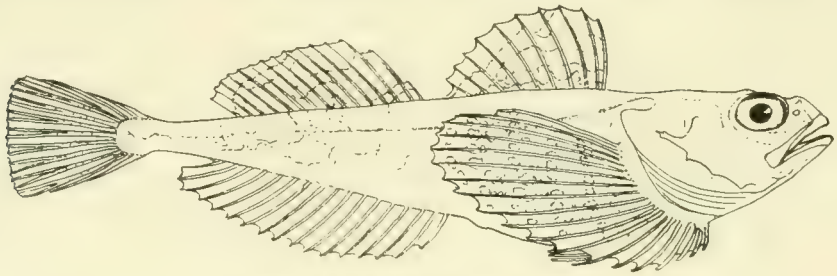

FIG. 158.—Staghorn sculpin (*Gymnocanthus tricuspis*). After Smitt

Color.—Described as dark brownish or gray above, the sides marked with dark crossbands or with alternate light and dark greenish spots. The belly is described as white or yellowish with an irregular line of demarkation between dark sides and pale belly. The dorsal and pectoral fins are pale, the former with three and the latter with four or five irregular dark brown or black crossbands. The ventrals and anal are yellow rayed, with membranes of the same color as the belly

Size.—About 10 inches long.

General range.—Arctic Ocean and North Atlantic, south to northern Norway on the European coast, and to Eastport, Me., on the American coast.

Occurrence in the Gulf of Maine—The most southerly record for this Arctic sculpin, and the only Gulf of Maine capture, is a specimen caught at Eastport, Me., in 1872, and now in the U. S. National Museum. It is only as a rare stray from colder waters to the east and north that it ever reaches the Gulf.

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[86] Scandinavian Fishes, 1892.

[87] A specimen from Labrador figured by Storer (1850, pl. 7, fig. 2) has longer and sharper spines than are credited to it by Jordan and Evermann or by Smitt.

[88] Unfortunately we had not seen this sculpin. In one recently examined the ventrals fall short of the vent.

124. **Deep-sea sculpin** (*Cottunculus microps* Collett)

Jordan and Evermann, 1896–1900, p. 1992.

Description—In this species the head spines, so characteristic of most sculpins, are reduced to bony knobs, of which there are four on the top and several on the sides of the head. The two portions of the dorsal fin (spiny and soft) are united into one continuous fin, a feature that marks it off from all other local sculpins, while the spiny part (only 6 spines) is shorter and lower than the soft part (19 rays). The very large bony head, wide mouth, slender tapering body, large fan-shaped pectorals, and the location of the ventrals below the pectorals, give the fish a typical sculpin aspect, however. The anal fin (about 10 rays) is slightly shorter than the soft portion of the dorsal, and the caudal fin is small and rounded. The skin is roughened with small warts.

Color.—Described as pale with dusky crossbars, one on the head, two on the body and fins, and one at the base of the caudal fin. Scandinavian specimens have been represented as showing still another band across the tip of the caudal and with the anal and pectoral fins dark mottled.[89]

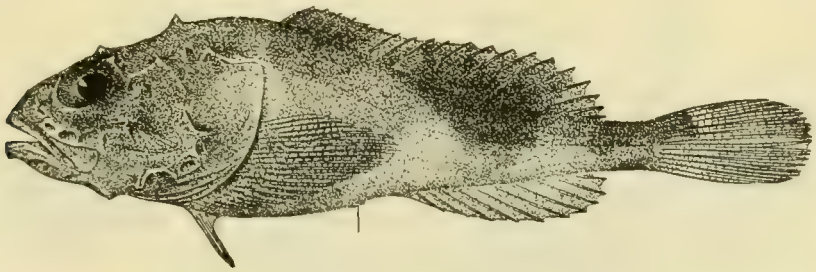

FIG. 159.—Deep-sea sculpin (*Cottunculus microps*)

Size.—About 8 inches long.

General range and occurrence in the Gulf of Maine.—This is a deep-water species known off east Greenland and about Spitzbergen in the Arctic Ocean and from both sides of the North Atlantic. Off the American coast it has been taken at numerous localities on the continental shelf and slope abreast of New England in depths of 122 to 487 fathoms. Its depth range in Scandinavian waters is about the same. Only two of these records fall within the geographic limits covered by this report—one in the extreme southeast corner of the basin of the Gulf (lat. 42° 23′, long. 66° 23′) in 141 fathoms, and the other in the eastern channel between Browns and Georges Banks (lat. 42° 15′, long. 65° 48′) in 122 fathoms, but this is enough to show that it is to be expected anywhere in the deep basin below 100 fathoms.[90] Nothing is known of its habits.

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[89] Smitt. Scandinavian Fishes, 1892.

[90] Goode and Bean (1896) list the American records.

125. **Sea raven** (*Hemitripterus americanus* Gmelin)

RED SCULPIN; SEA SCULPIN; RAVEN; TOADFISH; KING O'NORWAY

Jordan and Evermann, 1896–1900, p. 2023.

Description.—No one would be likely to confuse the sea raven with any other sculpin, for, as Jordan and Evermann (1896–1900, p. 2023) remark, it is "a most remarkable looking fish." It is stouter bodied than our other common sculpins, about three and three-fourths times as long as deep (counting caudal fin), with very large head. Both the jaws of its wide mouth are armed with several rows of very sharp teeth noticeably longer and stouter than the teeth of either the long-horned or the short-horned sculpins. Its most distinctive features, however, which identify it at a glance or a touch, are the fleshy tags, simple and branched, on the head; the outline of its dorsal fin; and the texture of its skin. There is a series of 4 to 8 of the tabs along each side of the lower jaw, three pairs on the top of the snout, and others, variable in number and size, above and in front of the eyes and along the upper jaws. There is also a short but high keel on the top of the snout with a deep

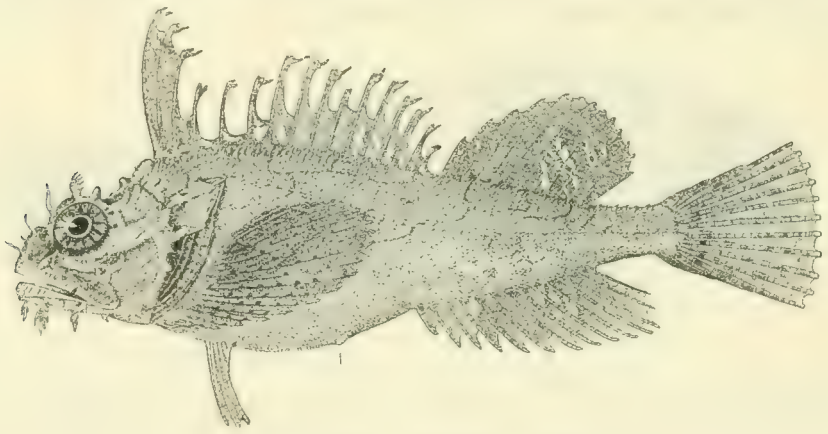

FIG. 160.—Sea raven (*Hemitripterus americanus*)

hollow behind it, another high ridge above, and a lower one below each eye. These, with about 12 rounded knobs on the crown and several low bosses, besides 2 short spines on each cheek give the head a peculiarly bony appearance.

The first two or three spines of the first dorsal fin are longest; the fourth and fifth spines are shorter than those further back, giving the fin an outline quite unlike that of any other sculpin; from the third spine backward the fin membrane is deeply emarginate between every two spines but expanded at the tips of the latter into irregular flaps; and the margin of the anal fin is similarly but less deeply scalloped between the rays. Furthermore the first dorsal fin originates further forward than in any other Gulf of Maine sculpin—that is, well in front of the gill opening—and is much longer (16 spines) than the second (12 rays), whereas in our other sculpins the second dorsal is longer than the first. The pectorals are fanlike and the caudal brush shaped as in other sculpins.

The entire skin of the sea raven, below as well as above, is prickly, the prickles being largest on the back and along the lateral line; smallest, but still obvious to the touch, on the lower sides and belly. In all other Gulf of Maine sculpins the belly is smooth. We may point out in passing that the ventral fins are fleshy, each with 3 rays only, not 4 as shown in Jordan and Evermann's illustration.

Color.—The sea raven varies in color from blood red to reddish purple, chocolate, or yellowish brown, but it is invariably paler below than above and usually with a yellow belly. Many are plain colored. For instance, one 18 inches long, which I caught off Mount Desert recently, was uniform red chocolate on back and sides, but others are variously mottled with a paler or darker cast of the general ground tint or even with white. The fins are variously barred with light and dark, the pectorals and anal often being yellow-rayed.

Size.—One of 25 inches and 5 pounds weight, mentioned by Storer, is the largest on record, but ravens are often 18 to 20 inches long and weigh from 2 to 3 pounds.

General range.—Atlantic coast of North America from Labrador, Newfoundland, and the Grand Banks to Chesapeake Bay. Most common east and north of Cape Cod.

Occurrence in the Gulf of Maine.—The geographic range of the sea raven in the Gulf covers the whole coastal belt from a fathom or two down to about 50 fathoms, including the passages among the islands that fringe Maine and Nova Scotia as well as the larger estuaries such as St. Mary, Passamaquoddy, Machias, Penobscot (it runs up the latter to its head at Bucksport), and Casco Bays, and the deeper harbors, for example Boston, Salem, Eastport, and St. Johns. Fishermen also report them on Cashes Ledge, while the otter trawlers and line trawlers pick up odd ones over the whole of Georges Bank and likewise on Browns, but it is not known to occur in the basin deeper than about 75 fathoms. Probably its lower limit is set as much by the character of the bottom as by depth, our own experience, confirmed by our various inquiries, being that ravens are to be caught only on rocky ground (which is its chief haunt from Massachusetts Bay northward), pebbles, hard sand, or clay (which it haunts off Cape Cod and on the offshore Banks), never on such soft sticky mud as floors the deeper sinks and the basin. There is no definite upper limit to its vertical wanderings other than the surface, but on the whole it keeps to deeper water than do the other sculpins common in the Gulf, being caught very seldom within the smaller estuaries and perhaps never on the tidal flats. At least we have never seen it in such situations at Cohasset, Mass., though it is not uncommon about the off-lying ledges close by.

Although so generally distributed in the Gulf, sea ravens seem to be nowhere abundant as compared with other sculpins; and this is as true in the Bay of Fundy as it is in Massachusetts Bay, where one expects to catch a few about any of the fishing ledges but where it would be unusual for one man to land any considerable number in a day. Similarly, the schedules of the catches made by certain otter trawlers in 1913 show that sea ravens are much less numerous on Georges Bank than are other sculpins. In fact, 15 was the most caught on any trip.

Habits and food.—Although this fish is so easily recognized that fishermen have long been familiar with it and scientists acquainted with it, little is known of its mode of life. Certainly it is quite as voracious as its relatives, for it takes any bait and is said to eat whatever invertebrates it finds on the bottom—e. g., mollusks (both bivalve and univalve), various crustaceans, sea urchins, and worms. Sea ravens also eat fish, Vinal Edwards having found herring, launce, sculpins, tautog, silver hake, and both sculpin and sea-raven eggs in specimens taken at Woods Hole.

The sea raven alone among Gulf of Maine sculpins has the power of inflating its belly like a balloon when lifted from the water. If thrown back again in this condition it floats helplessly on its back, feebly waving its tail to and fro, and we can not say whether it can deflate again at will like a puffer (p. 298) or must await the gradual escape of the air it has swallowed. Another point in which the raven differs from our other sculpins is that it can bite sharply, due to its larger teeth.

Off the southern shores of New England sea ravens work inshore in autumn and out again into slightly deeper water in spring, but no seasonal movement of this sort has been reported in the cooler waters of the Gulf of Maine; and apart from such bathic migrations (which, after all, mean merely that shoal water is too warm for their comfort in summer) sea ravens are resident throughout the year wherever found.

Breeding habits.—All that is definitely known of its breeding habits (to which we can contribute nothing first hand) is that ripe females have been found off southern New England in November and December; that the eggs are very large (about 4 mm. in diameter), yellow when first spawned, soon changing to amber color, and that they sink and stick together in masses.[91] The period of incubation is unknown. We can give no account of its larval stages, for the identity of the cottid larvæ referred to the sea raven by Agassiz and Whitman (1885) was not certain, but in summer, when the young have grown to about 1¾ inches (45 mm.), they are to be found on the bottom.

Presumably the sea raven breeds throughout its geographic range, but so far as we can learn the Bay of Fundy is the only part of the Gulf of Maine where fry as small as this have been definitely recorded. There, however, Huntsman found them on both the New Brunswick and on the Nova Scotian shore in summer.

Commercial importance.—Although the sea raven is said to be a good table fish (we have never tried it) there is no more market for it than for other sculpins in New England or Canada, but it is generally considered the best of all baits for lobster pots, hence shore fishermen save what ravens they catch for this purpose.

ALLIGATORFISHES. FAMILY AGONIDÆ

These curious little fishes are connected with the sculpins anatomically, though their general appearance gives no hint of the fact. Their most striking external feature is that the body is armed with several rows of overlapping plates. The only Gulf of Maine species somewhat suggests a pipefish in this and in its slender form, but the mouth being of ordinary form there is no danger of confusing it with the latter. Some agonids have a spiny dorsal fin and others lack it, while the ventrals of all are thoracic.

[91] Described by Bean (1903, p. 647). The pelagic eggs previously referred to this species (Agassiz and Whitman, 1885, p. 10) belonged to some other fish.

126. **Alligatorfish** (*Aspidophoroides monopterygius* Bloch)

SEAPOACHER

Jordan and Evermann, 1896–1900, p. 2091.

Description.—The readiest field marks for the identification of this curious little fish, so odd in appearance that it is not likely to be mistaken for any other, are that its entire head and body are clad with bony plates, that there is only one dorsal fin (the soft rayed), and that it is very slender (about 12 to 13 times as long as deep, not counting caudal), rather thicker than deep, and tapers rearward from the head to a very slender caudal peduncle. The plates are smooth, arranged in longitudinal rows as follows: A double row on the back running from the base of the head to just behind the dorsal fin where they unite into a single dorsal row (altogether 45 to 50 double and single plates along the back), two rows on each side, and two along the lower surface to just behind the anal fin, where they unite in one row. Thus the trunk is octagonal in front of the unpaired fins and hexagonal behind them. There are likewise two large and several small plates in front of each pectoral fin. The eyes are very large, with prominent ridges above them, and there are two sharp recurved spines on top of the nose. The mouth is small with minute teeth. The dorsal and anal fins (each of 5 or 6 rays) are fanshaped,

Fig. 161.—Alligatorfish (*Aspidophoroides monopterygius*)

one over the other about midway of the trunk. The caudal fin is small and rounded, the pectorals are larger than the unpaired fins, and the ventrals are reduced to one spine and two rays each.

Color.—The few we have seen have agreed with the published descriptions in being brown above with five or six darker brown or black crossbands and paler brown below.

Size.—Five to six inches long.

General range.—From west Greenland and the northeast coast of Labrador southward to Rhode Island and New Jersey.

Occurrence in the Gulf of Maine.—Being of no interest to fishermen, and living too deep to strand on the beach, this fish is seldom reported. It has been taken in 15 to 100 fathoms in the Bay of Fundy and in Passamaquoddy Bay, at Eastport, in 60 fathoms off Monhegan, near Portland, in 30 fathoms off Casco Bay, in Ipswich Bay, off Gloucester, Nahant, and Boston in Massachusetts Bay, off Provincetown, and off Cape Cod, records enough to show that it may be expected anywhere in the Gulf in depths of 10 to 100 fathoms and perhaps deeper. Goode and Bean (1879, p. 13) described it as abundant in the deeper parts of Massachusetts Bay, but our experience on the *Grampus* suggests "not uncommon" as a better description, our largest catches being 8 and 6 specimens from 32 fathoms

in Ipswich Bay and 27 fathoms in the inner part of Massachusetts Bay; and the fact that we found it at only 4 of our 10 trawling stations of 1912 (all in the western part of the Gulf) is in line with Huntsman's statement that it is found only occasionally in the Bay of Fundy.

Habits.—Nothing whatever is known of its life except that it is a bottom fish and that it has been repeatedly found in the stomachs of cod, haddock, and halibut, although it is not "much thicker or softer than an iron spike."[92] The *Grampus* trawled it both on pebbly bottom, on sand and broken shells, as well as on soft mud. So far as known adults never stray into water shoaler than 10 fathoms. Its breeding habits are unknown. Probably, however, its eggs sink like those of sculpins. The presence of its larvæ in Passamaquoddy Bay, off Boothbay, and near Seal Island, Nova Scotia, from April to June points to late autumn and early winter as the spawning season. It does not take to the bottom until of considerable size, for we have captured young as long as 29 mm. in the tow net (Bigelow, 1917, p. 272).

It is of no commercial value.

THE LUMPFISHES. FAMILY CYCLOPTERIDÆ

The lumps are characterized among Gulf of Maine fishes by their short, thick, high-arched bodies, the presence of a bony sucking disk on the chest with the very much reduced ventral fins as its center, and by the fact that the skin is set with tubercles.

KEY TO GULF OF MAINE LUMPFISHES

1. Body nearly round in cross section; skin tubercles sharply pointed. First dorsal fin persists throughout life ..... Spiny lumpfish, p. 339
   Body roughly triangular in end view; skin tubercles blunt. When adult, the first dorsal fin is entirely inclosed in the thick fleshy skin ..... Lumpfish, p. 334

127. **Lumpfish** (*Cyclopterus lumpus* Linnæus)

LUMP; LUMP SUCKER

Jordan and Evermann, 1896–1900, p. 2096.

Description.—The lumpfish is about twice as long (counting caudal) as deep, with a short head, and the dorsal profile of its trunk is much more arched than the ventral. There are seven longitudinal ridges on the body—one running along the back as a cartilaginous flap inclosing the first dorsal fin in adults and as two ridges from the latter to the second dorsal; one ridge on the upper part of each side over the eye; and two more ridges paralleling it lower down, the first close above the level of the pectoral and the second marking the boundary from side to belly. Each of these ridges is marked by a line of large pointed tubercles, and the entire skin between the ridges is thickly studded with small knobs. As a result of the presence of these ridges the trunk of the lumpfish is roughly triangular in end view, with flat belly (except when swollen by milt or roe) and sharp back, but the caudal

[92] Goode, et al., 1884, p. 258.

peduncle is rounded. The profile of the head is characteristic, being concave above, convex below, with terminal mouth, small teeth and eyes, and gill openings of moderate size. The first dorsal fin (visible only in very small specimens) is of 6 to 8 spines. The second dorsal and the anal below it are alike in outline, both of 9 to 11 rays, while the caudal is broad based and square tipped and the pectorals

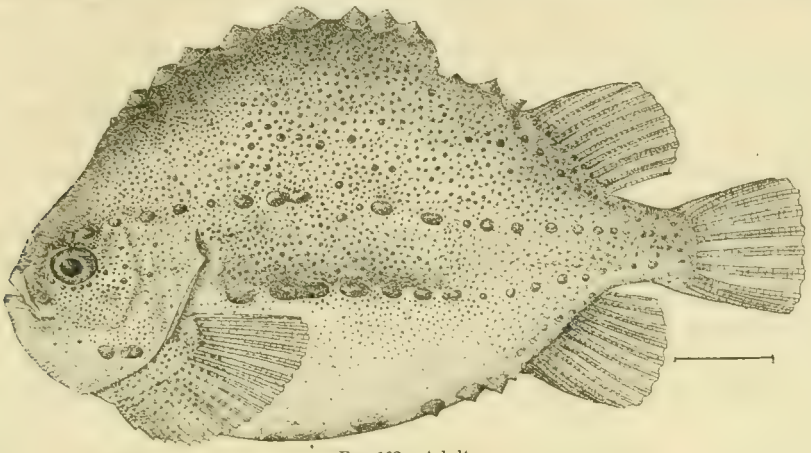

FIG. 162.—Adult

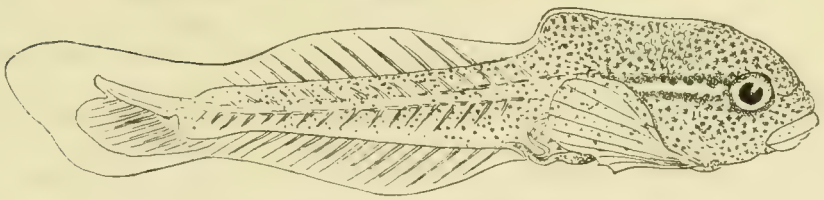

FIG. 163.—Larva, 4 to 5 millimeters. After Garman

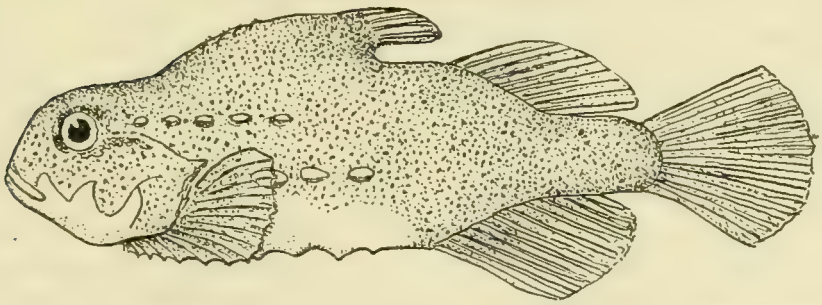

FIG. 164.—Fry, 34 millimeters. After Garman

LUMPFISH (*Cyclopterus lumpus*)

are large, rounded, and so broad based that they nearly meet on the throat. The ventrals are not visible as such, being altered into 6 pairs of fleshy knobs in the center of the sucking disk, surrounded by a roughly circular flap of skin. The entire disk, so formed, is about as wide as the width of the head and is situated close behind the throat.

Color.—Descriptions of this fish credit it with a great variety of tints and this we can corroborate. When adult the ground tint may be bluish gray, olive, brownish or yellow green, chocolate or kelp brown, or slaty blue, with the belly usually a paler or more yellowish cast of the same hue but sometimes whitish. During the breeding season the belly of the adult male turns red, brightest near the sucking disk. In some specimens the back and sides are marked with dark blotches and more or less dotted with black. Others, however, are plain colored or nearly so, except that the tubercles are usually dark tipped. Young lumpfish (and it is with such that we are ourselves most familiar) often match their surroundings very closely in color, usually being mottled olive green and ochre yellow with white belly when living among floating masses of rockweed, and sometimes with silvery dots and stripings.

Size.—On the American coast a length of 20 inches and weight of 18¾ pounds (a fish examined by Storer) seems to be the maximum, and few are larger than 14 to 16 inches long or heavier than 3 to 6 pounds. The largest we ourselves have seen was about 15 inches long.[93] Females average larger than males. Fulton,[94] for example, writes that 39 females taken in the Bay of Nigg (Scotland) averaged about 16 inches and 6 pounds, and 30 males only 11 inches and slightly less than 2 pounds.

General range.—Both sides of the North Atlantic, northward to Disko (lat. 70° N.) in West Greenland, Davis Straits, Hudson Bay, Labrador, Newfoundland, and the Gulf of St. Lawrence, and south to New Jersey (exceptionally to Chesapeake Bay) on the western side.

Occurrence in the Gulf of Maine.—The lumpfish is to be found all around the shores of the Gulf of Maine. It has been reported at Yarmouth and St. Mary Bay on the Nova Scotian side, and is abundant in all stages at various localities in the Bay of Fundy. There are many records for it along the Maine coast—e. g., Eastport, Penobscot Bay, off Seguin, and Casco Bay; it is common near Boothbay, and in Massachusetts waters where it has been reported repeatedly, as at Nahant, Swampscott, Plymouth, Truro, along Cape Cod, and at Monomoy. It even enters river mouths, but so far as we can learn never where the water is appreciably brackish. According to fishermen large lumps are seldom seen on the offshore banks, but we towed newly hatched larvæ (only 6 to 10 mm. long) on the northeast part of Georges Bank on July 23, 1914.

Habits.—The adult lump is primarily a bottom fish but is also made semi-pelagic by its habit of hiding in floating masses of rockweed. In European seas it covers a very wide depth range—from tide mark down to 150 to 200 fathoms, but we have never heard of one taken in more than a few fathoms in the Gulf of Maine. It is probably restricted to a comparatively shoal zone there by the nature of the bottom, if not by the absolute depth, for the soft sticky mud of the deeper basin can hardly be a favorable environment. Large lumpfish are usually found hiding in rockweed or holding fast by the sucker to stones or other objects. About Massa-

[93] Smitt (Scandinavian Fishes, 1892) gives 24 inches as the maximum for Scandinavian and European waters generally, apparently not accepting the enormous size (up to 48 inches) credited to it by Möbius and Heincke (Vierter Bericht, Kommission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel, 1883, p. 226).

[94] Twenty-fourth Annual Report, Fisheries Board for Scotland, 1905 (1906), Part III, p. 171. Glasgow.

chusetts Bay lobster pots are favorite resorts for them when set on stony bottom. For instance, W. F. Clapp tells us that one pot in every 8 or 10 will yield a lumpfish on the broken ground off the entrance to Duxbury Harbor. Lumps often hold to the lower sides of lobster cars, probably for their shade. Occasionally one is found clinging to one of the poles of a trap or weir, though this is a much less common event in the Gulf of Maine than in Scottish waters, where they are frequently caught in salmon nets set along shore. Welsh notes one entangled in a gill net set off Great Boars Head in April, 1913. They have (rarely) been found clinging to floating logs or inside a box or barrel. Sometimes they strand on the beach, and there is at least one record of a lump sucking to a mackerel.

The young fry swim at the surface, and we have taken them so often in our tow nets that we have learned to expect them wherever there are floating masses of rockweed (a refuge in which all but the smallest regularly hide or to the fronds of which they cling).

Most species of fish that are pelagic when young but live on the sea floor when adult leave the surface at a rather definite stage in growth. This hardly applies to the lump, however, for while most of those taken in tow nets or dipped up are less than 2 inches long, very large adults are sometimes seen at the surface, more often, perhaps, in the Bay of Fundy than elsewhere in the Gulf, and their presence at the surface is determined less by the age of the individual fish than by the presence or absence of floating seaweed.

Most of the young lumps have left the surface by winter; indeed very few have been taken at any depth in the Gulf of Maine during the cold months,[95] but we picked up one on the surface off Lurcher Shoal on April 12, 1920, and another off Yarmouth, Nova Scotia, on January 4, 1921. Although this is an ungainly fish it can swim more rapidly for a short distance by its vigorous tail strokes than its shape might suggest, and the young pelagic fry are very active.

Food.—We have no first-hand information to offer as to the diet of the lumpfish. In British waters this has been found to consist chiefly of isopods, amphipods, and other small crustaceans, with various other invertebrates—e. g., worms and soft-bodied mollusks—and its diet is much the same in the Gulf of Maine for Cox and Anderson (1922, p. 9) report euphausiid shrimps (Meganyctiphanes), fragments of jellyfish (Aurelia), amphipods (Hyperia), caprellids, and the remains of small fish in the stomachs of lumps from Passamaquoddy Bay. This is one of the few fish that regularly feed on ctenophores and Medusæ, and 25 specimens examined at Woods Hole by Vinal Edwards contained nothing but ctenophores. Lumps also eat fish, and large numbers of young clupeids have occasionally been found in their stomachs. But like most other fishes, they cease feeding during the spawning season.

Breeding habits.—So far as known the only regular migrations carried out by the lumpfish are the involuntary drifts of its young fry at the surface, and a general movement of the adults into shoal water at spawning time followed by an offshore migration after breeding is completed. In Scottish waters, where many observations have been made on the life of the lump,[96] spawning (and the corresponding

[95] Cox and Anderson (1922, p. 5) state that the Canadian Research steamer *Prince* has taken only two (both small) in the Bay of Fundy in winter.

[96] McIntosh, Fourteenth Annual Report, Fishery Board for Scotland, 1895 (1896), Part III, pp. 173–178, and Fulton, Twenty-fourth Annual Report, Fishery Board for Scotland, 1905 (1906), Part III, pp. 169–178.

inshore migration) takes place from February until near the end of May; and the evidence afforded by our tow nettings, if not conclusive, suggests an equally protracted spawning season in the Gulf of Maine, for on the one hand we have taken larvæ already 27 mm. long as early as May 10, and on the other, newly hatched larvæ (only 6 to 7 mm.) as late as June 19 in the inner parts of the Gulf and as late as July 23 on Georges Bank. In fact we took one only 10.5 mm. long on August 22 in 1912 off Seguin Island. In the Gulf of St. Lawrence, however, where vernal warming is later than in the Gulf of Maine, lumps probably do not commence spawning until the middle of April, for Cox and Anderson found no larvæ until late in June, their observations pointing to late May as the height of the breeding season there and to mid-June as about its termination,[97] assuming that the period of incubation is about as long in the Gulf of St. Lawrence as in European waters of like temperature—that is, six weeks to two months.

On the other side of the Atlantic spawning takes place in very shallow water chiefly close to low-tide mark, but the fact that the egg masses (more or less familiar objects on European shores) seem never to have been reported along the coast of the Gulf of Maine, although the local presence of larvæ is proof that lumps breed all around its periphery, suggests that the eggs are deposited at least a fathom or two down. Our capture of recently hatched larvæ over Georges Bank is evidence that the latter also serves as a spawning ground in 15 to 25 fathoms or deeper, but the lower limit to spawning is yet to be determined.

Females are prolific, large ones of 18 inches producing up to 136,000 eggs which sink and stick together in large spongy masses through which the water circulates freely. In north European waters these egg masses are often found adhering to rocks or other objects or in crannies near low-water mark, and watch should be kept for them along the rocky coast line of the Gulf of Maine. The male lump, like the sticklebacks, guards the eggs until they hatch, his courage and his devotion to his charge having often been described.[98] Throughout the period of guardianship, which he performs fasting, he constantly fans the egg mass, keeping it free of all silt and bathed in flowing water, never leaving it save to drive off some intruder. As soon as the eggs are hatched, however, his vigil ends, leaving him thin and exhausted. The females take no part in guarding the eggs but are said to move out into deeper water once they have finished spawning.

The eggs are 2.2 to 2.6 mm. in diameter, pink when first laid but soon changing to pale green or yellow and deepening in tint as development progresses. The larvæ are about 4 to 7.4 mm. long at hatching, shaped like a tadpole with large head and slender tail, swimming actively and soon able to cling with the sucker to any bit of weed. When 12 days old the yolk disappears. The fins are differentiated at 10 mm., at 34 mm. the tubercles begin to appear, and except for the large first dorsal and slender form the fry then show most of the characters of the adult.

[97] The lumpfish spawns from late May through June on the coast of Greenland, in April and May in the Baltic, and early in the spring in Norwegian waters.

[98] Fulton (Twenty-fourth Annual Report, Fishery Board for Scotland, 1905 (1906) Part III, p. 169) gives a very interesting eyewitness account of the spawning of the lump and the guardianship of the male parent over the eggs.

Lumpfish larvæ and fry of all sizes are to be taken throughout the summer, the smaller undoubtedly being that season's hatch, but the larger ones may be either those hatched earliest that spring or latest the preceding summer, for the varying stage of development reached by different individuals at various sizes proves that the rate of growth varies widely. Thus Cox and Anderson (1922) describe one Cape Breton specimen only 33 mm. long in July, but so mature in outline and in its dermal armature that it must have been at least a year old, whereas they found that in the Bay of Fundy the fry of the year grow to 40 or 50 mm. by December with yearlings averaging about 58 mm. in July and August. As they remark, the rate of growth is apparently about the same in the Bay of Fundy (which probably applies to the Gulf of Maine as a whole) as in Scottish waters, while in their slower growth Gulf of St. Lawrence lumps correspond to those taken about Helgoland. Presumably all Gulf of Maine lumps upward of 2½ inches long are in their second year. Cox and Anderson (1922) have attempted to trace the growth of older fish from the structure of the vertebræ, and while it proved difficult to trace the rings with certainty they determined the ages of a few Bay of Fundy specimens as follows: 50 to 74 mm. in the summer of the second year, 95 to 110 mm. (3¾ to 4⅛

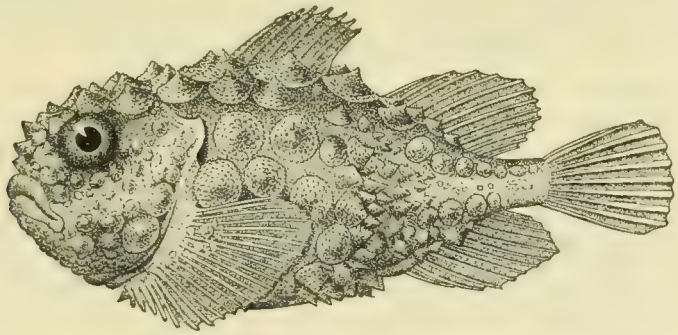

FIG 165.—Spiny lumpfish (*Eumicrotremus spinosus*)

inches) the third year, and 260 mm. (10¼ inches) the fifth year. Probably maturity is attained in the third year.

The lumpfish is said to be a favorite food of seals. Certainly it is so weak a swimmer that it would fall easy prey to them.

Commercial importance.—The lumpfish is never eaten in the United States and is of no other commercial value, but finds its way to our markets as a curiosity. At one time a few were consumed locally in parts of the British Isles and may be still.

128. **Spiny lumpfish** (*Eumicrotremus spinosus* Müller)

Jordan and Evermann, 1896–1900, p. 2098.

Description.—The spiny lumpfish is distinguishable from its commoner relative by the fact that its first (spiny) dorsal fin remains free through life instead of becoming inclosed by the skin, with the tubercles relatively much larger, sharper pointed, studded at the base with rough prickles, and irregularly but closely scattered over body and head. Furthermore its gill openings are much smaller, while its body is not so high arched and is nearly round in cross section instead of compressed.

Color.—Described as olivaceous to brownish.

General range.—Arctic and northern parts of the Atlantic Ocean south occasionally to the Gulf of Maine.

Occurrence in the Gulf of Maine.—Occasional specimens of this northern fish have been reported from Eastport, from off Cape Ann, and from Massachusetts Bay.

THE SEA SNAILS. FAMILY LIPARIDIDÆ

The sea snails are curious tadpole-shaped, soft-bodied little fishes, and, like the lumpfish, have a sucking disk on the chest supported by the vestigial rays of the ventral fins, but the skin is smooth and without tubercles and the spiny and soft dorsal fins are continuous as a single fin. The Gulf of Maine supports two species.

KEY TO GULF OF MAINE SEA SNAILS

1. Spiny (front) and soft (rear) portions of the dorsal fin are separated by a notch_____ Sea snail, p. 340
   There is no separation between the spiny and soft portions of the dorsal_____ Striped sea snail, p. 342

129. **Sea snail** (*Neoliparis atlanticus* Jordan and Evermann)

Jordan and Evermann, 1896–1900, p. 2107.

Description.—Perhaps the most noticeable character of this and of the striped sea snail (p. 342) is that due to the cylindrical fore part of the trunk, together with the broad rounded snout and fat soft belly, and the abrupt compression of the body close behind the vent, it is shaped more like a tadpole than like the conventional fish. It is also provided with a sucking disk similar to that of the lumpfish (p. 335). In side view the body is deepest abreast the pectoral fin (about four times as long as deep, without caudal), tapering evenly to a moderate caudal peduncle. The head is rather flat above, the mouth terminal and moderately wide, and the jaws are armed with many small teeth arranged in bands. The dorsal fin originates close behind the pectoral and runs continuously to the base of the caudal though separate from the latter. The most apparent difference between this species and the striped sea snail is that in the former the spiny portion of the dorsal (6 spines hardly stiffer than the soft rays) is demarked from the much longer soft part (25 rays) by a notch, whereas in the latter there is no such separation. The dorsal spines are longer in males than in females and project further beyond the membrane, giving the fin a fringed appearance. The anal fin (23 to 27 rays) originates under or slightly behind the soft portion of the dorsal, to which it corresponds in size and outline. The pectorals are not only very large and fanlike, but their bases run forward under the throat, where they expand into secondary lobes or wings with fringed edges. The ventrals appear only as a circle of low knobs in the center of the sucking disk, which is situated on the throat between the pectorals. The skin is scaleless, and is smooth except at spawning time, when the male is rough with small prickles.

Color.—Described as olive to reddish brown with lighter and darker cloudings and dots, the dorsal and anal fins often with crossbars. But not only do its tints vary widely, but also its markings and the strength of coloration, whether pale or dark, as is the case with so many bottom fishes.

Size.—Maximum length about 5 inches.

General range.—Rocky shores along the North American coast from Newfoundland and the Gulf of St. Lawrence to southern New England.[99] It is rare west and south of Cape Cod, but has been taken at Woods Hole and on the coast of Connecticut.

Occurrence in the Gulf of Maine.—This sea snail is generally distributed around the shore line of the Gulf. The *Halcyon* took it off Yarmouth, Nova Scotia, in January, 1921. It is rather common (according to Huntsman) in the Bay of Fundy and its tributary, Passamaquoddy Bay, and it has been definitely reported at Grand Manan, Eastport, Seguin Island, off Portland (where many have been collected), off Cape Elizabeth, at Kittery, and at various localities about Massa-

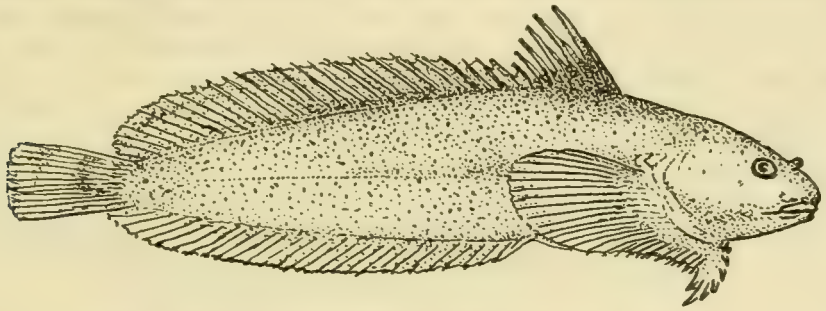

FIG. 166.—Male adult sea snail (*Neoliparis atlanticus*) side view. After Garman

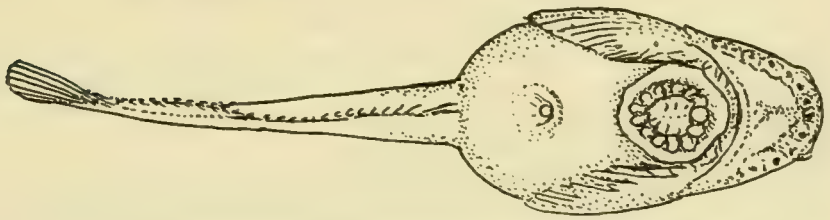

FIG. 167.—Male adult sea snail (*Neoliparis atlanticus*), ventral view. After Garman

chusetts Bay. As yet it has not been reported from Georges or Browns Banks, but is probably represented among the sea snails that have been found living in scallop shells on the latter (p. 344). It seems indifferent to depth within moderate limits, for while it has been dredged as deep as 50 fathoms at various localities in the Gulf, it is often found clinging to lobster pots in the Bay of Fundy as lumps often do in Massachusetts Bay (p. 337), and has been taken in but a few feet of water there also. Nor would it be surprising to find sea snails left in rock pools or on pebbly beaches by the ebbing tide, for this often happens with its European representative.

Habits and food.—Sea snails are inconspicuous little fish usually found coiled up, tail to head, under stones or attached by the sucker to some kelp stalk or other seaweed, but occasionally they swim to the upper water layers for the *Halycon* specimens just mentioned were taken in the tow net at 8 fathoms where the water was about

[99] This fish is so closely allied to the north European sea snail, *N. montagui* (from which, however, it is quite distinct), that it masqueraded under that name prior to 1898.

22 fathoms deep. Young ones have been found living within the shells of the giant scallop (*Pecten magellanicus*), a curious habit they share with the striped snail (p. 344), and with the hakes of the genus Urophycis (p. 449). Little is known of the life of this sea snail in the Gulf of Maine except that it is supposed to work inshore in winter to breed but usually keeps at some little depth in summer. Presumably it feeds chiefly on small crustaceans and small shellfish like its European relative.

Breeding habits.—The spawning of the American sea snail has not been observed. In North Sea waters the spawning season of the European *N. montagui* endures from February until April, rarely until July. Sea snails must spawn at least from March to midsummer in the Gulf of Maine, for Huntsman has found the larvæ in Passamaquoddy Bay as early as April while we towed one only 7 mm. long on German Bank as late as September 2, 1915. The eggs of the European fish, which are about 1.1 mm. in diameter, pale straw color to light salmon pink, sink and stick together in little clusters that adhere to hydroids, seaweeds, sticks, or débris of any kind. These clusters are often brought up on trawl lines from 4 to 30 fathoms and are sometimes found close up to tide mark. There is no reason to suppose that the males care for the eggs, and the latter are so hardy that they do not suffer even from exposure to the air for hours. Judging from the dates when newly hatched larvæ have been seen, incubation of the European species occupies a month—perhaps longer in the case of the eggs spawned earliest and at winter temperatures. The larvæ of the European *N. montagui* are about 3.3 to 4.5 mm. in length at hatching, with small rose red yolk sac containing a large oil globule and inclosed in a net of blood vessels. The yolk is absorbed in about 14 days when the larva is about 3.9 to 4.2 mm. long, and with further growth the body, which is at first elongate, becomes deeper and the head larger. The fin rays appear and the sucker is formed at about 7 to 8 mm., and most of the characters of the adult are apparent at 11 to 12 mm. length. Throughout the larval stage the pectoral fins are brilliantly pigmented with yellow and black.[1]

Commercial importance.—This little fish is of no importance either to the professional fisherman or to sportsmen, but it plays a rôle in the economy of the sea as food for larger fish, fry of its European relative having been found in cod stomachs.

130. **Striped sea snail** (*Liparis liparis* Cuvier)

SEA SNAIL

Jordan and Evermann, 1896–1900, p. 2116.

Description.—This little fish closely resembles the sea snail (p. 340), especially in its tadpolelike form, in the presence of a sucking disk in which the rays of the ventrals (reduced to mere knobs) serve as a central support, and in the peculiar outline of the pectorals with their secondary frilled basal lobes. The most obvious difference between the two species is that there is no separation between the spiny and the soft parts of the dorsal fin of the striped sea snail. Furthermore there are

[1] McIntosh and Mastermann (The Life-Histories of the British Marine Food-Fishes, 1897) and Ehrenbaum (Nordisches Plankton, Band I, 1905–1909) both give good descriptions of the larvæ of the European species from which the preceding is condensed.

more rays in both its dorsal and its anal fins—33 to 35 in the former and 26 to 29 in the latter as against a maximum of 32 dorsal and 27 anal in the other sea snail. Neither is the separation of the dorsal and anal fins from the caudal fin as definite in this species as in the preceding, and sometimes it is difficult to draw a sharp line between the two fins. A minor difference, which gives the head a rather different aspect, is that the dorsal profile is more arched.

Color.—Many color varieties of this fish have been described and named. As a rule the ground tint is some shade of olive green, gray, or brown, variously tinged with reddish, yellowish, or lilac and but little paler above than below, but red ones, pale and dark striped, have been seen among kelp in New England waters. In varying situations they are dark and pale in endless variety, some nearly plain, some definitely striped with few or many narrow longitudinal bands, others spotted, and no two alike. Usually the fins are darkly blotched or barred.

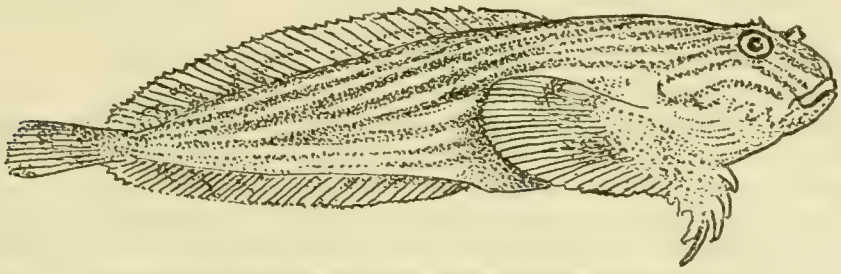

FIG. 168.—Adult striped sea snail (*Liparis liparis*), side view. After Garman

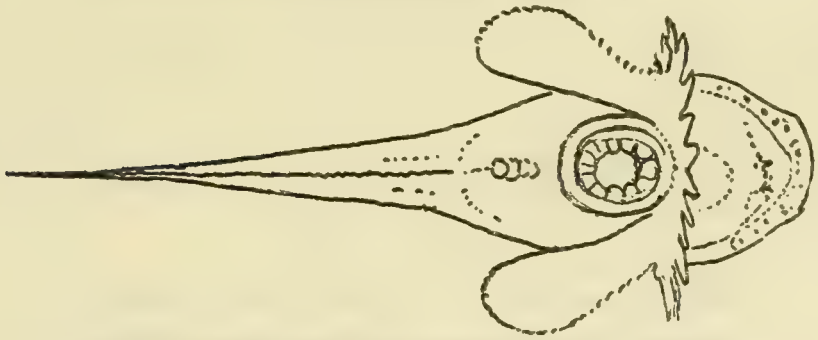

FIG. 169.—Adult striped sea snail (*Liparis liparis*), ventral view. After Garman

Size.—This fish grows to a length of 10 inches in Arctic seas but is seldom more than 5 inches long in temperate latitudes.

General range.—Both sides of the North Atlantic; north to Spitzbergen, Davis Strait, Labrador, and circumpolar, south to France and to New York.

Occurrence in the Gulf of Maine.—The distribution of this sea snail parallels that of the preceding species in the Gulf. It has been dredged not uncommonly in the Bay of Fundy region in from 5 to 100 fathoms and has been recorded from Grand Manan, Eastport, and other localities on the Maine coast, here and there about Massachusetts Bay, and also at Woods Hole.

Habits.—Although this fish is as common in the Gulf as the other sea snail, if not more so, all that is known of its habits there is that it lives on rocky or stony bottom, usually among the stalks and roots of kelp to which it sometimes clings fast, a habit which European writers describe as common. In British waters it is often to be found hiding in the tiny pools of water left under pebbles by the ebbing tide, and probably a search of the beaches would reveal it in similar situations in the Gulf of Maine but of this we find no definite report. Small ones often live inside the shells of the giant scallop (*Pecten magellanicus*), and it is our impression (though not backed by any definite evidence) that this is a more usual habit with this than with the preceding species. At any rate, W. F. Clapp informs us that it is the rule to find at least one or two sea snails in a bushel or so of scallops, and fishermen have told us that one or the other species of sea snail (probably both) is found in scallop shells on Georges Bank where the scallops are plentiful locally.

Food.—Small Crustacea, chiefly amphipods and shrimps of various kinds, have been found in stomachs of striped sea snails on both sides of the Atlantic, and it also feeds on small shellfish and was described by Fabricius[2] as eating small fish fry and algæ.

Breeding habits.—This fish is a winter spawner in the western Atlantic, as it is in the eastern Atlantic, females full of roe occurring at Woods Hole in December and January. Spawning continues until well into the spring, for the collection of the Museum of Comparative Zoology contains a female distended with eggs taken on April 1 many years ago. Females with running roe have likewise been taken in Scandinavian waters in May, and larvæ only 5.5 mm. long, which we towed near the Isles of Shoals on July 22 and in Massachusetts Bay on August 31 in 1912, must have been hatched from eggs spawned at least as late as May if not June.

The eggs[3] (about 1.5 mm.—0.06 inch—in diameter) sink and stick together in bunches, which usually adhere to hydroids, seaweeds, or other objects like those of the sea snail, and apparently incubation is about as long as with the latter—that is, at least a month. The larvæ are about 5.5 mm. long at hatching and they live pelagic until upwards of 16 mm. long, at which size the sucking disk is well developed.

This little fish is of no commercial importance.

THE SEA ROBINS OR GURNARDS. FAMILY TRIGLIDÆ[4]

The sea robins and their European relatives, the gurnards, suggest sculpins in their broad heads, slender bodies, large fanlike pectoral fins, the presence of two separate dorsal fins (a spiny and a soft rayed), and in the location of the ventral fins under the pectorals, but their entire heads are armored with rough bony and spiny plates. The Gulf of Maine is the northern limit of the family on the Atlantic coast of America.

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[2] Fauna Grœnlandica, 1780.

[3] Ehrenbaum (Nordisches Plankton, Band I, 1905–1909, p. 112) gives an account of eggs and larvæ in European waters, from which these lines are condensed.

[4] The so-called "flying" robin (*Cephalacanthus volitans*) was included by Holmes (1862) and by Adams (1873) in their lists of Maine and New Brunswick fishes, but in neither case was a definite locality record given. As it has never been reported north of Cape Cod before or since we do not feel obliged to include it as a Gulf of Maine species. It would attract attention at once by its tremendous rounded batlike pectoral fins, which reach almost to the base of the caudal when folded, and by the presence of a long spine on each cheek reaching back past the ventral fins.

KEY TO GULF OF MAINE SEA ROBINS AND GURNARDS

1. The pectoral fin reaches back only to the fifth or sixth ray of the second dorsal. The margin of the caudal fin is concave ..... Common sea robin, p. 345
   The pectoral fin is larger, reaching back to the ninth or tenth ray of the soft dorsal. The caudal fin is square ..... Red-winged sea robin, p. 348

131. **Common sea robin** (*Prionotus carolinus* Linnæus)

SEA ROBIN; ROBIN; GREEN-EYE

Jordan and Evermann, 1896–1900, p. 2156.

Description.—The large head, tapering body, and fanlike pectoral fins of the sea robin somewhat suggest a sculpin, but the robin is distinguished from all sculpins by the incasement of its entire head in bony plates, by its smaller mouth, the flat depressed dorsal profile of its snout, its large ventrals, and by the fact that the three lower rays of each pectoral are separate from the rest of the fin and modified into three independent feelers slightly dilate at the tips, a very noticeable and diagnostic feature. Furthermore the anterior margin of the upper jaw is concave in outline when viewed from above, not convex as with most fishes, giving the nose a very characteristic aspect. The head plates are rough and there is one sharp spine on each cheek, one at the angle of the gill cover, two short spines over each eye pointing backward, a spine on either side of the nape of the neck, and one on each shoulder above the base of the pectoral fin. The spiny and soft-rayed portions of the dorsal are separate but in contact at their bases. The former (10 spines) is rounded in outline, decidedly higher than the soft dorsal (13 rays), but the latter is considerably the longer. The caudal is of moderate size, its margin slightly concave. The anal (12 rays) is similar in outline to the soft dorsal, under which it stands. The pectorals (their 3 lower rays as just noted) are rounded in outline and so large that they overlap the anal and the second (soft) dorsal when laid back. The ventrals (each of 1 stiff spine and 5 rays) stand close behind the pectorals.

Color.—Sea robins are usually reddish brown (some more red and some more brown) above with the upper surface of the head redder than the trunk and the body irregularly banded or blotched with pale and dark, while the belly is dirty white to pale yellow. The presence of a dusky spot on the first dorsal fin between its fourth and fifth spines is characteristic. The second dorsal is more or less striped or marbled with pale and dark and the pectorals are usually reddish brown but sometimes blackish above, slaty below, their lower feelerlike rays brown at the base with white or orange tips. The ventrals are white.

Size.—The maximum length is 15 to 16 inches but few are more than a foot long.

General range.—Shoal water along the North American coast from the Bay of Fundy to South Carolina, chiefly south of Cape Cod.

Occurrence in the Gulf of Maine.—Plentiful though the sea robin is in Vineyard Sound few are taken north of Cape Cod. It has been reported from various localities about Massachusetts Bay—Truro, off Lynn, and Salem; most recently at Manchester, where Welsh saw several in the trap on June 29, 1913; and Prof. A. E. Gross informs us that he has often seen as many as a dozen "robins" taken in the trap at the entrance to Barnstable Harbor in a single tide in the early summer of 1920;[5] but I have never seen it about Cohasset or Duxbury. North of Cape Ann

[5] This is briefly mentioned in The Auk, Vol. XL, No. 1, January, 1923, p. 24.

it has been taken at Annisquam, at the mouth of the Saco River, and repeatedly in the neighborhood of Casco Bay. Here it appears so regular (if rare) a member of the local fish fauna that Dr. W. C. Kendall saw more than 25 taken from the traps near Small Point between July 4 and 14 in 1896, and the local fishermen were familiar with it; but the only record east of Small Point is for a single specimen caught at Campobello Island in the mouth of the Bay of Fundy in August, 1911. Being a shoal-water fish, it is confined to a narrow belt along the shores of the Gulf, but its

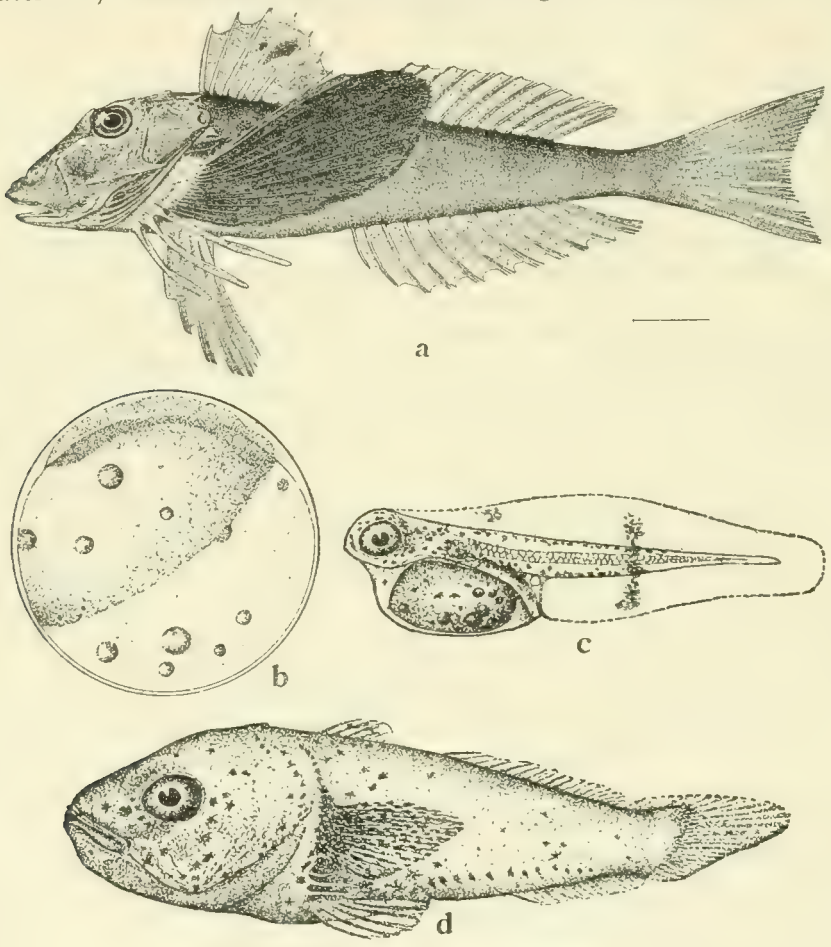

FIG. 170.—Sea robin (*Prionotus carolinus*)

a, Adult. *b*, Egg. *c*, Larva, just hatched, 2.8 millimeters. *d*, Fry, 9 millimeters.

range extends eastward across the south channel to Georges Bank, where the trawlers picked up a few (never more than a dozen or two on a trip) during the summer of 1913. Probably the Eastern Channel is its easterly limit, for "robins" are not known on Browns Bank or off the west Nova Scotian coast. In summer the depth range of the "robin" is from close below tide mark down to 30 or 40 fathoms—perhaps deeper.

Habits.—Along southern New England sea robins, like many other warm-water fish, leave the coast in October to reappear in April or early May, but it is probable that they merely move out into deeper water below the reach of winter chilling to pass the cold months. If any are resident in the Gulf of Maine they would no doubt follow this same program; and while the rarity of the fish, together with the facts that the earliest recorded date for it in Massachusetts Bay is for June 29 and that no young ones have been reported anywhere in the Gulf of Maine, suggest that the few taken north of Cape Cod have been immigrants, it is likely that once past the Cape they remain there, wintering offshore; that is, their status in the Gulf parallels that of the cunner in parts of the Bay of Fundy (p. 285). "Robins," like sculpins, keep to the bottom, where they often lie with the fanlike pectorals spread. When disturbed they bury themselves in the sand, all but the top of the head and eyes. In swimming the pectorals are usually closed against the body, and they are said to employ the feelerlike rays in stirring up the weeds and sand to rout out the small animals upon which they feed. They are usually found on smooth hard bottom; less often on mud or about rocks.

Food.—The sea robin is a very voracious fish, feeding indifferently on shrimps, crabs of various kinds, amphipods (crustaceans are its chief diet), squids, bivalves, annelids, and on small fish—e. g., herring, menhaden, and small winter flounders. Seaweed has also been found in sea robin stomachs.

Breeding habits.—It is doubtful whether this fish ever succeeds in reproducing in the Gulf of Maine unless in restricted localities, such as Casco Bay, where the summer temperature rises high; but although we have never taken its rather characteristic eggs in our tow nets it is probable that the few that sojourn north of Cape Cod spawn there, if vainly. About Woods Hole it spawns from June to September with July and August the peak of the season.[6] The sea robin, unlike the sculpin tribe, produces buoyant eggs, which are 0.94 to 1.15 mm. in diameter, slightly yellowish in color, with a variable number (10 to 25) of oil globules of unequal size, usually arranged in a more or less definite ring. At a temperature of 72° incubation occupies about 60 hours, but any eggs spawned in the cooler water of the Gulf would be slower in hatching. The newly hatched larvæ are 2.5 to 2.8 mm. long, with two transverse yellow bands, one close behind the pectoral fins and the other midway between vent and tail. The yolk is absorbed, the mouth formed, and the yellow markings no longer prominent in five days, at a length of 3 to 3.4 mm. The dorsal and anal fin rays are visible and the lower pectoral rays have separated from the remainder of the fin at about 9 mm., and young fish of 25 to 30 mm. are darker, with transverse bands, and show most of the anatomic characters of the adult.

Commercial importance.—Although the sea robin is edible, and its near relatives, the gurnards, serve as table fish in Europe, it is not marketable; and at any rate it is too scarce in the Gulf of Maine to be of any importance there either in human or natural economy. Off southern New England, where it is abundant, it is a nuisance to anglers, taking bait planned for better fishes, while hordes of robins sometimes enter the traps.

[6] Kuntz and Radcliffe (1918, p. 105–109) give an account of its embryology and larval stages, subsequently confirmed and supplemented by Welsh.

132. **Red-winged sea robin** (*Prionotus strigatus* Cuvier and Valenciennes)

Jordan and Evermann, 1896–1900, p. 2167.

Description.—The red-winged sea robin resembles the common sea robin so closely that one might easily be taken for the other, but its mouth is wider and gapes back almost opposite the front of the eye, with the maxillary bone more than one-third as long as the head. Its head is flatter (compare fig. 171 with fig. 170a), its pectoral fin is relatively longer (reaching back to the ninth or tenth ray of the second dorsal instead of only to the fifth or sixth), its pectoral feelers are more slender and tapering, its caudal fin is square-ended instead of emarginate, and its reddish or olive-brown sides (the general ground tint varies) are banded longitudinally below the lateral line with a dusky or bronze-brown stripe. However, the first dorsal shows the same black or dusky blotch between the fourth and fifth spines, so characteristic of the common robin. The pectorals are described (we have not seen it alive) as sometimes dusky, with crossbars and edged with yellow and sometimes

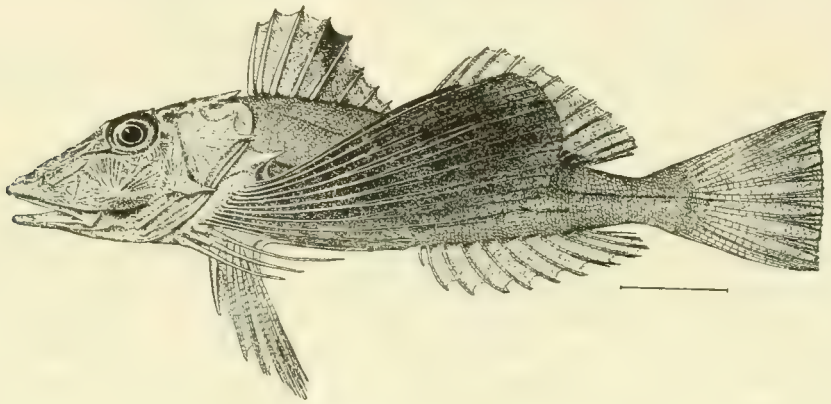

FIG 171.—Red-winged sea robin (*Prionotus strigatus*)

reddish brown above, hence the common name. The second dorsal is either plain brown or with two dark blotches at its base, and the gill covers are described as sometimes orange.

Size.—This is a larger fish than the common sea robin, growing to a maximum length of about 18 inches.

General range.—Shoal water along the Atlantic coast of North America from Massachusetts Bay to South Carolina, chiefly south of Cape Cod.

Occurrence in the Gulf of Maine.—This southern fish rarely rounds Cape Cod, there being but 5 definite records for the Gulf of Maine—Monomoy, North Truro, Salem, and Gloucester (the latter its most northerly outpost), and for the eastern part of Georges Bank, whence one was brought in to the U. S. Fish Commission sometime between 1877 and 1880.

THE REMORAS. FAMILY ECHENEIDIDÆ

The several remoras are easily distinguished from all other fishes by the fact that the spiny part of the dorsal fin is modified into a flat oval sucking plate composed of a double series of cartilaginous crossplates with serrated free edges situated on the top of the head and neck. All remoras, too, are slender of form with the lower jaw projecting far beyond the upper. Their large mouths are armed with many small pointed teeth, their soft dorsal and anal fins similar in form and size and one above the other, and their pectorals set high up on the sides. The lower surface of the head is convex, the upper flat—just the reverse of the usual rule—with the lower surface of the body as deeply colored as the upper, the back often being mistaken for the belly. The members of this family all attach themselves to other fishes or to sea turtles by their sucking disk, usually clinging to the sides of the hosts but often within the mouth or gill cavities of the larger sharks and giant rays.[7] Thus they are carried about, and they feed on the scraps of the meals of their transporters. All remoras are tropical, and they appear only as strays in boreal seas, usually fast to sharks or swordfish.

We follow Sumner, Osborne, and Cole (1913, p. 766) in uniting under one species the shark sucker (*naucrates*), with more than 21 plates but a sucking disk less than one-fourth as long as the body, and the pilot sucker (*naucrateoides*), with only 20 or 21 plates but longer sucker—fishes that are otherwise indistinguishable, one from the other.

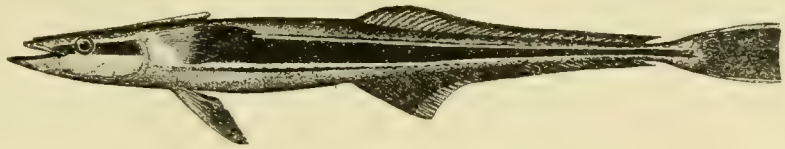

FIG. 172.—Shark sucker (*Echeneis naucrates*)

KEY TO GULF OF MAINE REMORAS

1. Pectoral fins pointed; ventrals attached to the belly for less than one-third their length ---------- Shark sucker, p. 349
   Pectorals rounded; ventrals attached to the belly for more than half their length----- 2
2. Dorsal fin of 29 rays or more; at most 16 plates in the sucker---- Swordfish sucker, p. 350
   Dorsal fin of only about 23 rays; about 18 plates in the sucker--------- Remora, p. 351

133. **Shark sucker** (*Echeneis naucrates* Linnæus)

PILOT SUCKER; WHITE-TAILED SUCKER

Jordan and Evermann (*Echeneis naucrates* and *E. naucrateoides*), 1896–1900, pp. 2269–2270.

Description.—The most diagnostic characters are mentioned above. This is a very slim fish, 11 or 12 times as long as deep, nearly round in section, and tapering to a very slender caudal peduncle. The sucking disk, extending from close behind the tip of the snout as far back over the nape of the neck as the middle of the pectoral fin, is about as broad as the head, flat, oval, and with very conspicuous transverse plates 20 or more in number. This disk is the most notice-

[7] Gudger (Natural History, Vol. XXII, No. 3, May–June, 1922, p. 243–249) gives an interesting account of this habit.

able feature of the fish. The soft dorsal (32 to 41 rays) and anal (31 to 38 rays) fins both originate about the mid length of the body and extend nearly to the base of the caudal. Both taper, too, from front to rear, but the latter is more falcate than the former. The caudal fin is slightly emarginate in old fish but in young ones its central rays are the longest. The ventrals are pointed like the pectorals, below which they stand, and their inner rays are attached to the skin of the abdomen for only a short distance. The broad-based pectorals are set so high on the sides that their upper margins are close below the overlapping edge of the sucking disk.

Color.—The general ground tint is slaty or dark brownish gray, with the belly as dark as the back. Each side is marked by a broad darker brown or sooty stripe with white edges, running from the angle of the jaw to the base of the caudal fin but interrupted by the eye and by the pectoral, and broadest close behind the latter. The caudal fin is velvety black with white corners, a character noticeable enough to have given rise to a vernacular name. The dorsal and anal fins are dark slate color or black, more or less margined with white. The pectorals and ventrals are black, either plain or more or less pale edged.

Size.—About two feet long.

General range.—Cosmopolitan in warm seas, north to Massachusetts Bay on the Atlantic coast of North America.

Occurrence in the Gulf of Maine.—So far as we can learn no shark sucker has been reported from the Gulf for many years; in fact, the only positive records of it north of Cape Cod are for one taken from the bottom of a fishing boat in Boston Bay some time prior to 1839 (described and illustrated by Storer, 1853–1867, p. 210, pl. 32, fig. 3), a second reported by Wheatland (1852) from Salem Harbor (reidentified by Goode and Bean as *naucrateoides*), and a third reported by Goode and Bean (1879, p. 20, as *naucrateoides*) as taken at the mouth of the Merrimac River in June, 1870. It is only as the rarest of strays that it ever wanders north of Cape Cod, clinging to some ship (for such is a common habit in its tropical home) or to a shark.

134. **Swordfish sucker** (*Remora brachyptera* Lowe)

Jordan and Evermann, 1896–1920, p. 2272.

Description.—This is a stouter fish than the shark sucker (p. 349), being only about seven times as long as deep (counting caudal fin) and about as thick through the shoulders as deep, with a thicker caudal peduncle; and although the sucking disk is as long, relatively, there are only 14 or 15 plates. Furthermore the pectoral fins are relatively shorter than those of the shark sucker, softer, and rounded instead of pointed, while because of the deeper body the upper margins of these fins are not so close to the edge of the sucking disk. The ventrals, too, are attached to the skin of the abdomen along their inner margins for at least one-half their length, as noted above (p. 349). Its long dorsal fin (29 to 32 rays) and the small number of plates in the sucking disk serve to separate it from the remora (p. 351).

Color.—Described as light reddish brown above and darker below with paler dorsal and anal fins. A diagnostic feature is that it lacks the side stripes and white fin edgings so characteristic of the shark sucker.

Size.—A length of 12 inches is the maximum so far recorded.

General range.—Warm seas generally, probably paralleling that of the swordfish.

Occurrence in the Gulf of Maine.—Goode and Bean's (1879, p. 21) description of this sucker as not unfrequently accompanying swordfish into Massachusetts Bay

FIG. 173.—Swordfish sucker (*Remora brachyptera*)

probably applies to the whole Gulf except the Bay of Fundy, for specimens have been brought in from near Matinicus Rock and near the Isles of Shoals, while fishermen occasionally speak of seeing "suckers" clinging to the swordfish they harpoon on the offshore Banks. Sometimes several are fastened to a single swordfish, but they also report far more swordfish lacking than carrying these uninvited guests, and as this has been the case with the few fish harpooned by the *Grampus* during our cruises in the Gulf we have never seen it in life.

Habits and food.—Nothing except the bare fact just mentioned is known of the habits of the swordfish sucker. Presumably it feeds on fragments of the fish killed by its host, as does the shark sucker whose actions are better known. Presumably, too, it is as active a swimmer as are its relatives. Suckers are described by eye-witnesses as usually fast to the shoulder of the swordfish, nor have we heard of one actually within the gill cover of the latter, though very likely they refuge there as do others of their tribe in the mouths and gill cavities of large sharks (p. 349). Nothing whatever is known of their breeding habits.

135. **Remora** (*Remora remora* Linnæus)

Jordan and Evermann, 1896–1900, p. 2271.

Description.—The chief distinction between the remora and the swordfish sucker is that there are more plates in its sucking disk (about 18 as against 14 to 15),

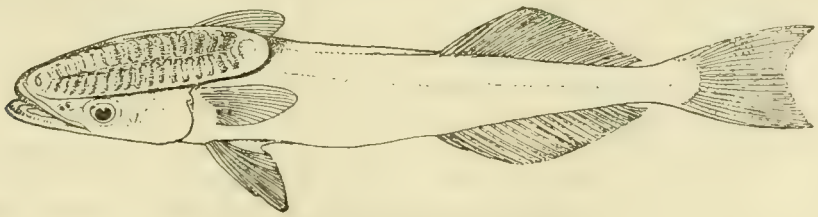

FIG. 174.—Remora (*Remora remora*). After Day

and there are only about 23 rays in its dorsal fin whereas the swordfish sucker has 29 to 32. Like the latter it is a stouter fish than the shark sucker (p. 349), and its ventrals are similarly attached to the skin of the abdomen along their inner edges.

Color.—Uniform blackish or sooty above and below.

Size.—Maximum length about 15 inches.

General range.—Tropical seas generally, very common in the West Indies, rarely north to New York and to Woods Hole, and only casual north of Cape Cod. It is usually attached to large sharks or sea turtles.

Occurrence in the Gulf of Maine.—The only Gulf of Maine record is for a specimen said to have been taken in Salem Harbor, whither, as Goode and Bean (1879, p. 21) remark, it was probably carried clinging to the bottom of some vessel in from a southern voyage.

THE TILEFISHES. FAMILY MALACANTHIDÆ

These are sea bass like in appearance, but with the soft (rear) portion of the dorsal much longer than the spiny (anterior), and the ventral fins thoracic in location. The only species that occurs off the northeastern United States is characterized by a large fleshy flap on the nape, suggesting, though not corresponding to, the adipose fin of salmons and smelts. This, however, is not shared by its relatives.

136. **Tilefish** (*Lopholatilus chamæleonticeps* Goode and Bean)

Jordan and Evermann, 1896–1900, p. 2278.

Description.—The presence of a thin, high, fleshy, finlike flap on the nape of the neck in front of the dorsal fin, close behind the eye, suggesting in its appearance but not in location the adipose fin of the salmon tribe, serves to identify the tilefish at a glance from all other Gulf of Maine fishes. This flap is as high as the dorsal fin, much higher than long, and rounded at the tip. Equally diagnostic, if less conspicuous, is a smaller fleshy flap situated on the side of the lower jaw close to the angle of the mouth, pointing backward (to be seen in the illustration, fig. 175). The outline of the large head is strongly convex in dorsal profile and nearly flat in ventral profile, with the eye high up and the mouth wide, both jaws being armed with an outer series of large conical teeth and inner rows of smaller teeth. The trunk (moderately compressed sidewise) is deepest close behind the head, tapering thence backward to the flattened caudal peduncle. The spiny and soft portions of the dorsal fin are continuous, extending back from above the gill opening almost to the base of the caudal, as is the case in cunner, tautog, and rosefish; but in the tilefish the soft part (14 to 15 rays) is two to three times as long as the spiny portion (7 spines). The caudal fin is small for so large a fish, with concave margin. The anal (14 to 15 rays) is about half as long as the dorsal fin, under the rear (soft) part of which it stands, and like the latter it is of nearly even height throughout most of its length except that its anterior corner is rounded. The ventrals stand below the pectorals, which are set low on the sides, and both pectorals and ventrals are pointed. Trunk and gill covers are clothed with large scales.

Color.—This is a brilliant fish with back and upper sides bluish or olive green, changing to yellow or rosy on the lower sides, and with its belly of the latter tint with white midline. The head is tinged reddish on the sides; pure white below. The back and sides above the level of the pectorals are thickly dotted with small

irregular yellow spots, particularly conspicuous below the adipose dorsal flap. The dorsal fin is dusky with similar but larger yellow spots, its soft portion pale edged. The adipose flap is greenish yellow, the anal is pale pinkish clouded with purple and with bluish iridescence, and the pectorals are pale sooty brown, with purplish reflections near their bases.

Sizes.—Tilefish have been reported up to 50 pounds in weight, but this is unusual. The largest fish we ourselves have seen (an unripe female) weighed 35½ pounds and was about 42 inches (108 cm.) long. Measurements taken by Bumpus (1899, p. 329) and more recently on the *Grampus* show that a 40-inch fish may be expected to weigh about 30 pounds; fish of 33 to 36 inches, 20 to 21 pounds; and 30 to 32 inch fish, 17 to 18 pounds.

General distribution and occurrence in the Gulf of Maine.—The geographic range of the tilefish is surprisingly circumscribed for a fish as large and locally as plentiful, for it is known only along the outer edge of the continental shelf and on the upper part of the slope abreast the east coast of the United States. The

FIG. 175.—Tilefish (*Lopholatilus chamæleonticeps*)

longitude of the South Channel (69° W.) is about its eastern limit. How far it ranges to the southward is still to be determined, but none have been reported dead or alive below latitude 37° 29′ N.—that is, a few miles north of the mouth of Chesapeake Bay. Along this zone the tilefish lives on the bottom in depths of 50 to about 200 fathoms, with the best fishing in 60 to 65 fathoms. Few are caught much deeper than 100 fathoms and none below 200, as far as we know. Thus the tilefish touches only the extreme southwest corner of our limits, but so interesting are its history and its relationship to hydrographic conditions that it deserves more attention than its status as a "Gulf of Maine" fish would demand.

To begin with, it is surprising that the very existence of this large fish so close to our coast should have been unsuspected until May, 1879, when Captain Kirby, cod fishing in 150 fathoms of water south of Nantucket Shoals lightship, caught the first specimens on his line trawl, as has often been narrated. These, and others caught in 87 fathoms in the same general region the following July by the schooner *Clara T. Friend* (Capt. William Dempsey), drew so much attention that the Bureau of Fisheries sent several trips thither during the two subsequent years, resulting in the demonstration that the tilefish was so abundant within the depth limits

outlined above that it offered the opportunity for an important new fishery. These early investigations likewise proved that it occupies a very definite environment, for it lives only along the upper part of the continental slope and on the outer edge of the shelf where the inner edge of the Gulf Stream bathes the sea floor as a band of warm water (47 to 50°), and never ventures into the lower temperatures on the shoaling bottom nearer land on the one hand, nor (so far as known) downward into the icy Atlantic abyss on the other. Along this narrow band it ordinarily finds the temperature not only warmer than the waters on either hand, but varying by only a couple of degrees from season to season, and in addition a bounteous supply of invertebrates to prey upon. But the balance between the physiological nature of the fish and its surroundings is so delicate that it lives in constant danger of disaster, and hardly had its range been mapped when a submarine catastrophe overtook it. The first news of this disaster came in March, 1882, when the master of a vessel reported dead and dying fish on the surface, and throughout that month and the next vessel after vessel reported multitudes of dead tilefish floating on the surface between the latitudes of Nantucket and Delaware Bay. Digestion of all these reports [8] outlined the area of destruction as at the least 170 miles long by 25 broad—that is, an area of at least 4,250 square miles, and probably half as large again, thus covering the entire zone inhabited by the tilefish north of Delaware Bay. At least a billion and a half dead tilefish were sighted.

It has generally been supposed (and we believe correctly) that the destruction was caused by a sudden but only temporary flooding of the bottom along the warm zone by abnormally cold water, consonant with which is the fact that other species of fish suffered as well, and that dredgings carried on the following autumn proved that the peculiar invertebrate fauna characteristic of this warm zone in previous summers had likewise been exterminated. Unfortunately, however, no temperatures were taken on the tilefish ground at the season when the mortality occurred, and by the end of the following August the bottom water had again warmed to 48 or 49°.

So complete, indeed, was the destruction of the tilefish that fishing trials carried on off southern New England by the Bureau of Fisheries later in 1882, 1883, 1884 (when a particularly careful search was made and when the bottom water along the tilefish ground was as warm as it had been in 1880 and 1881), 1885, 1886, and 1887 did not yield a single fish.[9] But though decimated almost to the vanishing point, the species was not quite extinct, as most people had come to believe, the *Grampus* proving this by catching 8 off Marthas Vineyard in 1892. From that time on the tilefish gradually reestablished itself, though the building up of the stock must have been a slow process at first, for five trips and 18 sets of the line trawl yielded only 53 in 1893. Tilefish were next heard of in 1897, when a fishing schooner caught 30 of 6 to 15 pounds weight on a haddock line trawl south of Marthas Vineyard, and they had once more become so numerous by 1898 that the

[8] Collins (1884b) has described the event in detail, as have many subsequent authors. An account will also be found in Economic Circular No. 19 of the U. S. Bureau of Fisheries.

[9] I have elsewhere summarized (Bulletin, Museum of Comparative Zoology at Harvard College, Vol. LIX, 1915, p. 237) the temperatures taken in this region during the early years of the bureau.

Grampus caught 363 fish, of one-half to 29 pounds in weight, on three trips each of only one to three days' duration. During the next 17 years the tilefish was kept in view by occasional trips to the grounds by the bureau's vessels for that express purpose. On the *Grampus*, for example, we caught 19, weighing about 350 pounds, on August 26, 1914, in one hour's set off Marthas Vineyard in 105 fathoms. In October, 1915, the bureau, believing the tilefish capable of supporting an important fishery and knowing it to be an excellent food fish, undertook to popularize it in the market as has been described in the commissioner's report for the year in question, and it proved so plentiful and so easily caught on the line trawl that the first trip stocked 38,383 pounds in 27 days, although the best bait and the most productive localities were all to be learned. The fishery grew so rapidly at first that the landings for the first eight months after its inception aggregated upward of 4,388,500 pounds, with a grand total of 11,641,500 pounds from July 1, 1916, to July 1, 1917. But for some reason (and the taste of the consuming public is hard to analyze) the demand did not hold up; consequently fewer vessels now visit the grounds, and the catches have diminished so that the landings at Massachusetts ports were smaller for the whole of 1919 (188,180 pounds) than for the month of July alone in 1916. And although the market is better in New York, tilefish fishing is not likely to prove regularly profitable except in a small way and for special markets, as long as the price of better known fish, such as cod and haddock, remains as low as it has been for the past few years.

Habits.—Very little is known of the life history of the tilefish. Presumably it is resident on the grounds throughout the year, for its presence there has been established as early in the season as March and as late as January, while there was no general falling off in the autumn and early winter catches during the one year (1917–18) for which monthly data are available. The length of the period which the fish required to reestablish itself after the mortality of 1882, together with the fact that in 1898 the catch included a considerable number of young fish, is good evidence that the replenishment of the stock was chiefly the result of local reproduction, though it may have been recruited to same extent by immigration from the southern part of the range, where destruction may not have been as complete as it was north of Delaware Bay.

It is certain that the eastern limit of the tilefish fluctuates from year to year. Sometimes, as in September, 1898, the fish spread to the south channel (longitude 69°). Evermann (1905, p. 85) records the capture of a small one on Banquereau Bank (lat. 44° 26′, long. 57° 13′), which is the most easterly and northerly record for the species, but it has never been reported in any numbers east of longitude 69°. In July, 1916, for instance, the *Grampus* found none on the southwest slope of Georges Bank (long. 68° 15′ W.) nor abreast of Marthas Vineyard, but made a fair catch off New York. More thorough study of the movements of the tilefish might show that it works eastward during the summer with the gradual warming of the water, to withdraw to the westward again in autumn or winter, and warm or cold years no doubt largely govern such expansions and contractions of its range. For example, 1916 was a very cold summer in these waters.

Food.—The capture of tilefish on trawl and hand lines on bottom proves that it is a ground fish, as does the nature of its food, for a great variety of bottom-dwelling invertebrates have been taken from tilefish stomachs. Crabs, of which they are often packed full, are the most important article of diet. The list [10] also includes squid, shrimp, shelled mollusks, annelids, sea urchins, sea cucumbers, and anemones. Occasionally they catch other fish, two spiny dogs, for instance, having been found in one, and an eel (probably a conger or a slime eel) and unidentified fish bones in others.[11] The presence of pelagic amphipods (Euthemisto)[12] and of salpæ in the stomachs of tilefish caught on trawl lines proves that they sometimes feed at higher levels, but they are never known to rise to the surface voluntarily and when hauled up they are often "poke blown."

Tilefish take any bait—perhaps menhaden best, salt herring not so readily. Although they are strong active fish it is probable that they suffer from the attacks of sharks, for fish caught on the trawl lines are often bitten in two, and we have seen numbers of sharks 7 to 8 feet long (species not determined) follow them up to the surface while the line was being hauled.

Breeding habits.—Ever since the tilefish was discovered it has been known to spawn in July, and eggs were running from 10 out of 11 females caught by the *Grampus* off New York on the 29th in 1916, while the roe of the eleventh was still unripe. How early the spawning season may open is still to be learned, however, though August probably sees its close, for among 18 females caught on the 26th of that month in 1914 the majority were spent, only one or two still having running eggs. Among the fish that we ourselves have examined females have greatly predominated (only 1 male to 29 females in a total of 30 individuals).

It is safe to say that the eggs are buoyant and about 1.35 mm. in diameter, for the tow net yielded eggs of this size, indistinguishable from those stripped from the ripe fish, at the station where the ripe females just mentioned were caught; but the larval stages have not been seen, nor is anything known of the rate of growth or of the age of the tilefish at maturity.

Commercial importance.—This is one of the better, though not the choicest, food fishes, good boiled or baked, and delicious for chowder. It also makes a good smoked fish, and the sounds are valuable for isinglass.

THE TOADFISHES. FAMILY BATRACHOIDIDÆ

These fishes are somewhat sculpin-like in appearance, but the resemblance is only superficial, for the ventral fins are situated on the throat well in front of the pectorals ("jugular"), and there are only three gills and gill arches. Both soft and spiny portions of the dorsal are present as separate fins, the former much longer than the latter. Most of the species belong to warm seas, only one reaching the Gulf of Maine.

[10] Linton (Bulletin, United States Fish Commission, Vol. XIX, 1899 (1901), p. 471), notes by Vinal Edwards, and our own observations.

[11] The menhaden credited to the diet of the tilefish by Sumner, Osburn and Cole (1913, p. 767) were merely the pieces of bait on which the fish were caught.

[12] Collins, 1884b, p. 244.

137. **Toadfish** (*Opsanus tau* Linnæus)

Jordan and Evermann, 1896–1900, p. 2315.

Description.—The toadfish, like the sculpins, has a large flat head, round nose, tremendous mouth, tapering body with plump belly, and fanlike pectoral fins; but it differs from all sculpins, and indeed from all other spiny-finned fishes of the Gulf of Maine except the blennies (p. 359), in the location of its ventral fins, which are under the throat well in front of the pectorals ("jugular") instead of below or behind the latter. Nor could anyone confuse it with any blenny, for it is not only a totally different looking fish, but its dorsal fin is mostly soft rayed while that of the blennies is spiny throughout. The presence of fleshy flaps of irregular outline on the tip of the upper jaw and along the edge of the lower jaw, on the cheek, and over each eye, gives its head a peculiar warty appearance. Distinctive, also, is the

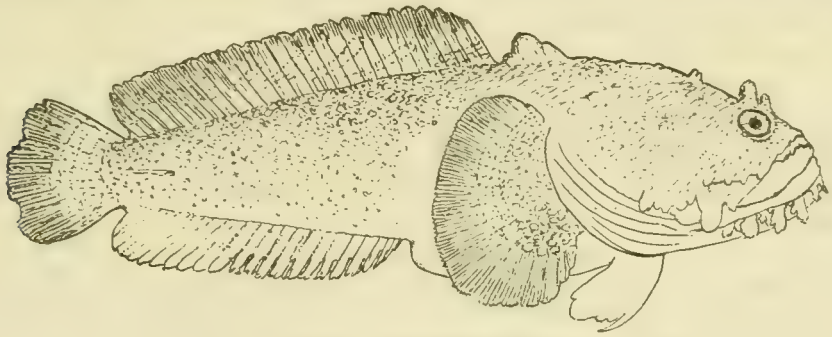

FIG. 176.—Adult. After Storer

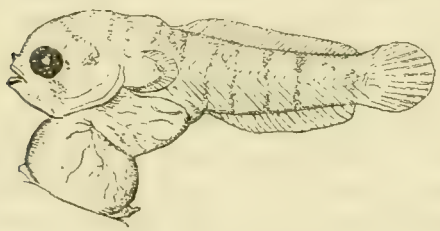

FIG. 177.—Larva, 8 millimeters

TOADFISH (*Opsanus tau*)

fleshy nature of all the fins and the outline of the dorsal, the soft part of which (26 to 28 rays) is five to six times as long as the spiny part (three spines), from which it is entirely separated by a deep notch, the two together extending the whole length of the trunk from the nape nearly to the base of the caudal. The anal (24 rays) is somewhat shorter than the second (soft) dorsal, originates under about the eighth ray of the latter, and is similar to it in outline except that its margin is deeply incised between every two rays, especially in its forward half. The caudal fin is irregularly rounded; the ventrals are jagged in outline, with the first ray stouter than the others, and covered by thick fleshy skin. There is a large open pit of

unknown function in the axil of each pectoral fin. We need only remark further that the skin is covered with a thick layer of slimy mucus, making the toadfish as loathsome a fish to handle as it is repulsive in appearance, and that there are no scales, the teeth are large and blunt, and there are two short spines at the upper angle of the gill cover, hidden, however, in the thick skin.

Color.—The general ground tint ranges from dark muddy olive green to brown or yellow, darker on back and sides, paler below, and variously and irregularly marked with darker bars and marblings, which may be restricted to head and fins or extend over the whole fish, belly as well as back. And the toadfish, like many other bottom fishes, changes color to match the bottom on which it lies.

Size.—Exceptionally 15 inches but seldom more than 12 inches long.

General range.—Shoal water along the east coast of North America from Cape Cod to Cuba, and casually northward to Maine.

Occurrence in the Gulf of Maine.—Although the toadfish is very common about Woods Hole and thence westward, like sundry other southern fishes it so rarely ventures around Cape Cod that none of the fishermen in Massachusetts Bay of whom we have inquired have seen or heard of it there, nor further north. In fact there are only three definite records of it in the Gulf of Maine—"Maine,"[13] Kittery(?), and Cohasset on the south shore of Massachusetts Bay, where one (now in the collection of the Boston Society of Natural History) was caught by Owen Bryant.

Habits and food.—The toadfish lives in shoal water, is resident the year around wherever found, and probably becomes torpid in winter in the northern part of its range. It is commonest on sandy or muddy bottom, hiding among eelgrass or under stones where it hollows out dens in which it lies in wait for prey. It is voracious and omnivorous, Vinal Edwards's diet list for it at Woods Hole including blood worms (Nereis), amphipods, shrimps, crabs, hermit crabs, a variety of mollusks both univalve and bivalve, ascidians, squid, and fish fry such as alewives, cunners, mummichogs, menhaden, puffers, sculpins, scup, silversides, smelt, and winter flounders. No doubt any small fish is acceptable.

Toadfish often snap viciously when caught, and fight among themselves. Like some sculpins they grunt, especially at night or if handled, and in spite of their clumsy appearance can dart out of their hiding places and back again with surprising speed.

Breeding habits.—In the northern part of its range the toadfish spawns in June and early July. The very large eggs (about 5 mm. in diameter) are laid in holes under stones, under large shells, in old tin cans, among sunken logs, or among eelgrass, where they adhere in a single layer to whatever serves as a nest, which the male guards during the three weeks or so occupied by incubation. Even after hatching the tadpole-shaped larvæ remain attached to the "nest" by the yolk sac until the latter is absorbed, when, at a length of 15 to 16 mm., they break free.[14]

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[13] Storer (1846a) gives no definite locality.

[14] Ryder (Bulletin, United States Fish Commission, Vol. VI, 1886 (1887), p. 8) and Gudger (Bulletin, United States Bureau of Fisheries, Vol. XXVIII, 1909 (1910), pp. 1071–1109, Pls. CVII–CXIII) describe the breeding habits, eggs, and larvæ of the toadfish. For further accounts of its habits see Gill (Smithsonian Miscellaneous Collections, Vol. XLVIII, 1907 pp. 388–427.)

THE BLENNIES. FAMILY BLENNIIDÆ

The blennies are characterized among the Gulf of Maine fishes by the location of the ventrals, which are well in front of the pectorals, combined with a single dorsal fin spiny throughout and running the whole length of the trunk, and with an elongate and sometimes eel-like form. The only Gulf of Maine species that resemble them are the wolffish and the wrymouth, but both of these lack ventral fins, which are present in all our blennies, though they may be very small. Furthermore, the tremendous canine tusks and molar teeth of the wolffish (p. 370) have no counterpart among the blennies, and the peculiar face of the wrymouth is equally diagnostic for it (p. 368). The eelpout (Zoarces) is also somewhat blennylike in appearance, but the greater part of its dorsal fin is soft, not spiny, and there is no demarkation between its anal and caudal fins.

The blennies are a numerous tribe of carnivorous shore fishes of small size, widely distributed both in northern and in tropical seas. Four species are known in the Gulf of Maine.

KEY TO GULF OF MAINE BLENNIES

1. Ventral fins very small, less than one-fifth as long as the pectorals; a row of large black spots along the back extending out on the dorsal fin ..... Rock eel, p. 359
   Ventral fins well developed, at least one-third as long as the pectoral; not black spotted along the back 2
2. More than 55 dorsal spines; body elongate, at least 8 times as long as deep; no lateral line visible 3
   Less than 50 dorsal spines; body only about 7 times as long as deep. Radiated shanny, p. 366
3. General form extremely elongate, about 15 times as long as deep; pectoral fins rounded, their middle rays longest ..... Snake blenny, p. 363
   Only moderately elongate, about 8 times as long as deep; the lower rays of pectorals much longer than the upper ..... Shanny, p. 365

138. **Rock eel** (*Pholis gunnellus* Linnæus)

BUTTERFISH; GUNNEL

Jordan and Evermann, 1896–1900, p. 2419.

Description.—The slender flexible trunk (only about one-ninth as deep as long and one-half as thick as deep), short head, and rounded nose of this little blenny suggest an eel, but the spiny nature of its dorsal fin betrays its true relationship. The fin (73 to 86 spines) extends from the nape back over the whole length of the trunk to the base of the caudal, from which it is marked off by a shallow notch only, and is of uniform height from end to end. The anal (two very short spines and 37 to 44 rays) originates midway of the dorsal, to which it corresponds in height and outline, and similarly runs back to meet the caudal with which it is continuous. The latter fin is small and rounded. The tiny ventrals, set near together close in front of the pectorals, are reduced to one very short spine and a rudimentary ray each. The pectorals are smaller than in our other blennies, hardly longer than the dorsal fin is high and oval in outline. The skin of the trunk is clothed with very small scales, hardly visible, however, through the thick layer of slimy mucus with which the rock eel is covered. The head is naked, the mouth small and set

oblique, with its upper jaw armed with several rows of conical teeth, the lower jaw with a single row only.

Color.—A row of about 10 to 14 round black-centered and pale-edged spots, spaced at equal distances along the middle of the back and spreading out onto the dorsal fin, are the most characteristic feature of the color pattern of this fish. The ground tint of the upper part is yellowish, reddish, or olive brown, with pale, irregularly rounded cloudings on the sides, and an oblique streak from the eye to the angle of the jaw. The belly varies from pale gray to yellowish white. The pectorals, caudal, and anal fins are yellowish. At Boothbay we have seen a

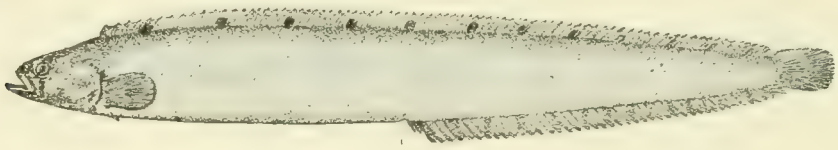

FIG. 178.—Adult

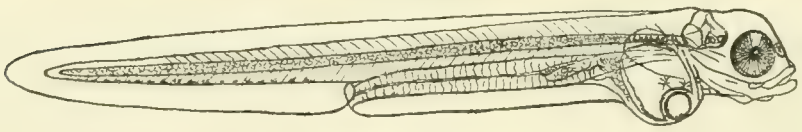

FIG. 179.—Larva (European), 9.4 millimeters. After Ehrenbaum

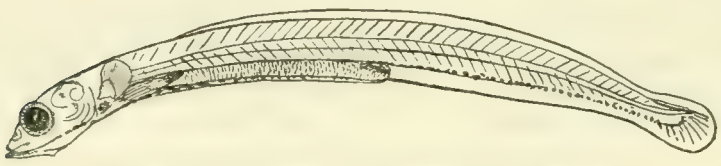

FIG. 180.—Larva (European), 18 millimeters. After Ehrenbaum

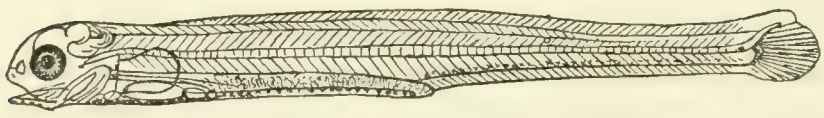

FIG. 181.—Larva (European), 20 millimeters. After Ehrenbaum

ROCK EEL (Pholis gunnellus)

specimen brick red above and below, light and dark mottled, flecked with tiny black dots, and with the spots on the dorsal fin dark red instead of black.

Size.—The maximum length is about 12 inches but few of those found are more than 6 to 8 inches long.

General range.—Shoal waters on both sides of the North Atlantic from Hudson Straits to New Jersey on the American coast and south to France on the European coast; commonest north of Cape Cod and north of the English Channel.

Occurrence in the Gulf of Maine.—This little fish is to be found all along the shores of the Gulf from Nova Scotia to Cape Cod. It is definitely recorded at Yarmouth (Nova Scotia), at various localities on both sides of the Bay of Fundy where it occurs nearly everywhere (writes Doctor Huntsman), at half a dozen

points along the Maine coast, at Portsmouth (N. H.), in Ipswich Bay, here and there along the north shore of Massachusetts Bay, and at Provincetown. We can add that it is to be found at Cohasset, Mass., and W. F. Clapp assures us he has seen many while shore-collecting for mollusks among the stones and bowlders of the Gurnet, off Plymouth, as well as at Hampton Beach, N. H., while A. H. Clark, of the U. S. National Museum, reports it plentiful about Portsmouth. No doubt it is even more universal, in suitable locations, than these records indicate, for being of no consequence to the fisherman or angler it comes to notice only when scientific collections are made, but it is certainly rather local. In some places one is to be found under almost every stone; at others you may turn rocks in vain. Its presence or absence along any particular stretch of shore probably depends on the character of the bottom immediately outside, it being a lover of pebbly, gravelly, or stony ground, or of shell beds and not of mud or eelgrass. Nor have we found it about the steep ledges so numerous along rock-bound coasts in the Gulf of Maine.

Habits and food.—So far as known rock eels are confined to very shoal water, most of them living within 2 or 3 fathoms of the surface, and perhaps none deeper than 15 fathoms, 13 fathoms (near Woods Hole) being the deepest actual capture with which we are acquainted, for which reason it is not likely that they occur on the offshore Banks. They are often found along low tide mark, left by the ebb in the little pools of water under stones or among seaweed where they await the return of the tide. Many have been seined on gravel bottom in a few feet of water. When uncovered they are usually lying partially coiled, and in Scandinavian waters, according to Smitt,[15] they often take refuge inside large empty mussel shells, but, as he remarks, there is no ground for the accusation that rock eels enter and devour live bivalves of any sort. When disturbed they squirm like eels. Eel-like, they swim by sidewise undulations, and they are so active and so slippery (hence the name "butterfish") that it needs quick work to catch one by hand even in a very small puddle. Very little is known of the diet of the rock eel except that it is carnivorous and that various molluscan and crustacean fragments have been found in its stomach. Vinal Edwards records small amphipods, shrimps, and worms in the few examined at Woods Hole, but we have no first-hand information to offer on this point. In their turn, rock eels have been found in the stomachs of various larger fishes, especially of cod, in Massachusetts waters.

So far as known the rock eel is resident throughout the year wherever found. At most it may move out from the beach into slightly deeper water in winter to escape chilling.

Breeding habits.—It is necessary to turn to European sources for information on its breeding habits, for its spawning has not been seen in American waters. In the eastern Atlantic and North Sea region generally [16] it spawns from November to February or even March, and since eggs probably belonging to the rock eel have been found off Rhode Island late in December,[17] no doubt it is similarly a

[15] Scandinavian Fishes, 1892.

[16] Masterman and MacIntosh (The Life-Histories of the British Marine Food-Fishes, 1897) and Ehrenbaum (Wissenschaftliche Meeresuntersuchungen, Helgoland, neue Folge, Band 6, 1904, p. 160) give accounts of its spawning and larval development.

[17] Tracy, 1910, p. 151.

late autumn and winter breeder in the Gulf of Maine. The eggs (by European accounts) are about 2 mm. in diameter, whitish opaque, iridescent on the surface, with a single globule of about 0.6 mm., and are laid in holes or crannies where they stick together. In British waters the rock eel usually chooses empty oyster shells or holes made in the limestone rocks by the boring bivalve Pholas, but there being no oysters in the Gulf of Maine, except in Cape Cod Bay, and the local Pholas being unable to bore into the hard granite rocks of our coast line, the rock eels must seek other nesting sites. Perhaps large mussel shells may serve them, or any crevice in lieu of the latter. The eggs are adhesive, and both the parents have been observed rolling the eggs into balls or clumps an inch or so across, in which they stick together, by coiling around them. In European waters incubation occupies from 6 to 10 weeks, during which period the parent fish of both sexes have been seen lying close beside the egg clumps, but since Ehrenbaum [18] described the parent as "very negligent" of the latter in the aquarium it seems that they merely seek the nesting holes as convenient shelters, and not that they actually guard the nest.

In the North Sea region rock eels spawn from between tide marks, as in Scotland, down to 12 fathoms or more, as at Helgoland where eggs have been found in the oyster beds, and probably the depth of spawning within these moderate limits is governed by the ability of the fish to find suitable nesting sites. The larvæ are much larger at hatching (about 9 mm.) and further advanced in development than those of most of the fishes that lay buoyant eggs, with the mouth already formed and the yolk sac small, and the latter is absorbed by the time the little fish have grown to about 13 or 14 mm. in length. Older larvæ of the rock eel resemble corresponding stages of the launce and of the snake blenny in their extremely slender form, but they are among the most easily recognized of fish larvæ in the Gulf of Maine, being distinguishable from both these species by the presence of a row of small black pigment spots below instead of above the intestine, and from the herring (the only other very slender larvæ apt to be met in any numbers in the Gulf at the same season) by the location of the vent about midway of the body (p. 97) and by the rounded, not forked, tail.

The caudal rays are visible in larvæ of 17 mm., the dorsal and anal fin rays are fully formed and the ventrals present at 20 to 25 mm., and the 12 black dorsal spots so characteristic of the adult are first noticeable against the transparent trunk in young fry of 25 to 30 mm. Up to this time they live at the surface, where they are taken at Woods Hole from April on. We have towed them (20 to 39 mm. long) off Seal Island (Nova Scotia), on German Bank, near Mount Desert Island, off Matinicus Island, and off Ipswich Bay, in April, May, June, and August (a total, however, of only six stations), while Huntsman states that they are caught in early summer in the Bay of Fundy. At a length of 30 to 40 mm. the young fish, now showing most of the adult characters, sink to the bottom, an event which takes place in late summer or early autumn in the Gulf of Maine, judging from what has just been said. Nothing definite is known of the rate of growth of the rock eel after its first autumn. This little fish is of no commercial importance.

[18] Wissenschaftliche Meeresuntersuchungen, Helgoland, neue Folge, Band 6, 1904, p. 161. Kiel und Leipzig.

139. **Snake blenny** (*Lumpenus lampetræformis* Walbaum)

SERPENT BLENNY

Jordan and Evermann, 1896–1900, p. 2438.

Description.—This is a very slender little fish, as its name implies, being only about one-fifteenth as deep as long, slightly compressed, with moderately long head, very large eye, wide mouth, and blunt snout. It somewhat suggests a launce (p. 183) in general form, but its rounded tail (that of the launce is forked), its large pectorals, spiny dorsal (the launce has a soft dorsal), and the fact that its lower jaw does not project beyond the upper, together with its color, serve to separate it from the launce at a glance. The chief anatomic feature distinguishing it from the rock eel, as noted above (p. 359), is that its ventral fins (each of one short spine and three longer rays) are well developed and one-third to one-half as long as the pectorals, slightly in advance of which they stand. The pectoral, too, is much larger and the dorsal and anal about twice as high, relative to the depth of the body, as in the rock eel, while the anal fin originates farther forward, the separation of dorsal and anal fins from the caudal is more evident, and the eyes are noticeably

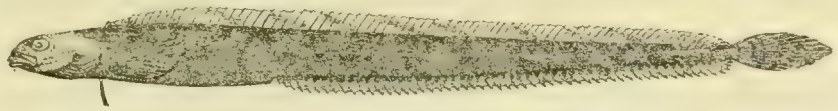

FIG. 182—Snake blenny (*Lumpenus lampetræformis*)

larger. The even rounded outline of the pectoral is the most obvious difference between this species and its close ally, the shanny, in which the lower pectoral rays are much longer than the upper (p. 365). The outline of the caudal fin, which is oval (more pointed in large than in small fish), with the central rays much longer than the outer ones, is likewise diagnostic.

Color.—The snake blenny is much paler than is usual for the rock eel, described (we have not seen the adult in life) as brownish or greenish yellow, its sides and back with many (about 20) faint brown blotches, its dorsal fin barred obliquely with about 12 and its caudal transversely with about 6 dark bands.

Size.—One of about 16 inches described by Storer (1867) from Massachusetts Bay is the largest on record.

General range.—Arctic and North Atlantic Oceans, south to Scotland on the eastern side and to Massachusetts on the western side.

Occurrence in the Gulf of Maine.—This northern fish finds its southern limit in the Gulf. Huntsman (1922a) reports it from St. Mary Bay in August and September, from Passamaquoddy Bay from April to August, and in the open waters of the Bay of Fundy from January on, so that it is by no means uncommon in the northeast corner of the Gulf; and although definite knowledge of the adult on the coast of Maine is confined to an Eastport record for 1872, it probably occurs all around the shores of the Gulf at some little depth, for Goode and Bean (1879, p. 10) described it as a common resident of the deeper waters of Massachusetts Bay. We have never trawled it, but it would not be surprising if it should finally prove both

widespread and as plentiful as it is in the western Baltic (where it is now known to be a common bottom fish, though formerly looked on as decidedly rare), for we took its pelagic larvæ off Seguin Island, near Cape Elizabeth, over Platts Bank, near the Isles of Shoals, off Ipswich Bay, off Cape Ann, off Boston Harbor, and in the southwest basin of the Gulf off Cape Cod during March, April, and May, 1920. It has not been reported on the offshore banks, but may be expected there.

Habits.—Little is known of the habits of the snake blenny on either side of the Atlantic. Although it is not found along the littoral zone, it is a fish of comparatively shoal water, never taken as deep as 100 fathoms (so far as we have been able to learn) and apparently most common from a fathom or so below tide mark down to 40 or 50 fathoms; while as most of the specimens that have been caught in Scottish waters were picked up by the foot rope of the otter or beam trawl, Sim's [19] suggestion that it burrows in mud or clay bottom is probably correct.

Food.—Amphipods, copepods, and other tiny crustacea, with very small starfish, small bivalves, and holothurians have been found in snake-blenny stomachs in British seas. These blennies are eaten in their turn by large fish—cod and halibut, for example, in Massachusetts Bay,[20] pollock in the Bay of Fundy, and cod in Northumberland Strait, Gulf of St. Lawrence, as Capt. Thor Iversen informed Doctor Huntsman from his experience during the Canadian Fisheries Expedition of 1915.

Breeding habits.—The spawning season has been stated as autumn or winter in north Scandinavian seas on the strength of Nilsson's [21] report of the capture of a spent female at Christmas time, consonant with which is the fact that its larvæ have been taken in tow nets from February to March in the Baltic on the one side of the North Atlantic and from March to May in the Gulf of Maine on the other. It may, however, commence spawning by late summer or early autumn, Sim having found its roe well advanced in development as early in the season as the end of April.

Neither the ripe fish nor the eggs of this species have ever been seen, but the latter probably sink and stick together like those of its relative, the rock eel. Apparently the larvæ are of considerable size at hatching, for the smallest we have taken (the smallest on record) were about 11 mm. long, though they still lacked any trace of the dorsal and anal fin rays. Snake-blenny larvæ are very slender, resembling the corresponding stages of the rock eel and of the launce in general appearance, but are distinguishable from both of these species by the fact that the vent is situated considerably in front of the midlength of the trunk. A still more diagnostic feature is the presence of a large black chromatophore at the base of each pectoral fin and a double row of 6 to 9 black spots along the dorsal surface of the intestine with several about the vent, which are very conspicuous by contrast with the colorless body, whether it be transparent in life or opaque white after preservation. The first traces of the dorsal and anal fin rays are to be seen at a length of 20 to 21 mm., while the tiny ventral fins are visible in a specimen of 34 mm., and our largest

[19] Journal, The Linnean Society, Zoology, Vol. XX, 1890, p. 38. London.
[20] Goode and Bean, 1879, p. 10.
[21] Skandinavisk Fauna, vol. 4, 1855, p. 195. Lund.

example (41 mm. long) shows most of the characters of the adult, although it is still transparent and with the arrangement of pigment characteristic of the earlier larval stages. Apart from the pigment there is no danger of confusing the young of the snake blenny with the herring, which is the only other very slender pelagic fish larva (besides rock eel and launce) that is apt to be found in any numbers in the Gulf of Maine in spring, for the tail of the herring is forked from a very early stage and its vent is situated much farther back than that of the blenny (p. 97).

140. **Shanny** (*Leptoclinus maculatus* Fries)

LANGBARN

Jordan and Evermann, 1896–1900, p. 2433.

Description.—The shanny closely resembles the snake blenny in general appearance and in the location and shape of its unpaired fins, but it is not so elongate (only eight instead of fifteen times as long as deep). The most important point of difference is that the lower part of the pectoral fin (5 or 6 rays) is much longer than the upper and obliquely truncate, as appears in the illustration (fig. 183). Its tail, too, is only slightly convex in outline instead of narrowly oval or pointed as in the snake blenny. Furthermore there are fewer fin rays—only 58 to 61 dorsal spines and 34 to 37 anal rays, as pointed out above (p. 363).

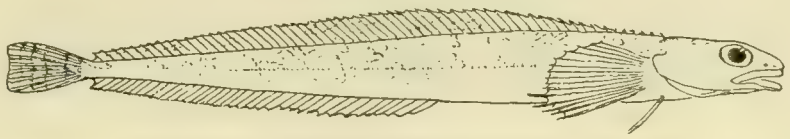

FIG. 183.—Shanny, European (*Leptoclinus maculatus*). After Collett

Color.—Dirty yellowish, paler below, the back and sides marked with indistinct yellowish-brown blotches of various sizes. The dorsal fin is described as barred obliquely with about 10 rows of brownish dots and the pectoral transversely with about 5 rows, but in the only specimen we have examined these fins showed no markings. The caudal fin, however, had a broad but indistinct dark crossbar.

Size.—About 7 inches long.

General range.—An Arctic fish, south to Sweden and Norway on the eastern side of the North Atlantic and to Massachusetts Bay on the western side.

Occurrence in the Gulf of Maine.—Several specimens of this Arctic fish collected in 40 to 90 fathoms in Massachusetts Bay by the U. S. Fish Commission in 1877,[22] and one that we took in the tow net at 30 fathoms near Boone Island on March 4, 1920, are the only records of it in the Gulf of Maine, where it appears only as a chance straggler from the north, to be sought in cold water in the bottom of deep isolated sinks. In such situations it may perhaps maintain itself in small numbers within our limits.

Habits and food.—In Scandinavian waters it spends most of the year in deep water, probably coming up to the shallows to spawn, however. In the aquarium it

[22] Presumably the "Gulf of Maine" specimens reported by Kendall (1914, p. 62), now in the United States National Museum, are this lot.

"keeps close to the bottom, with the body extended and the pectoral fins expanded, and apparently supports itself on the free lower rays of those fins",[23] this being all that is known of its mode of life. Annelid worms and pelagic amphipods have been found in shanny stomachs. It is supposed to spawn in winter, but neither its eggs nor its larvæ have ever been seen.

141. **Radiated shanny** (*Ulvaria subbifurcata* Storer.)

Jordan and Evermann, 1896–1900, p. 2440.

Description.[24]—This is a much stouter fish than either the snake blenny (p. 363) or the shanny (p. 365), being only about one-fifth as deep as long. The dorsal profile of the head is more convex than the ventral, the lips thick and fleshy, the eye of moderate size, and the lateral line bifurcate with its lower branch running the whole length of the body but the upper branch (which is much the more obvious of the two) reaching only about as far back as the tip of the pectoral fin. It is easily distinguished from the rock eel, which it most nearly resembles, by its larger ventrals, their situation farther in advance of the pectorals, the relatively greater height of the dorsal fin (compare fig. 184 with fig. 178), the fact that there are fewer fin rays

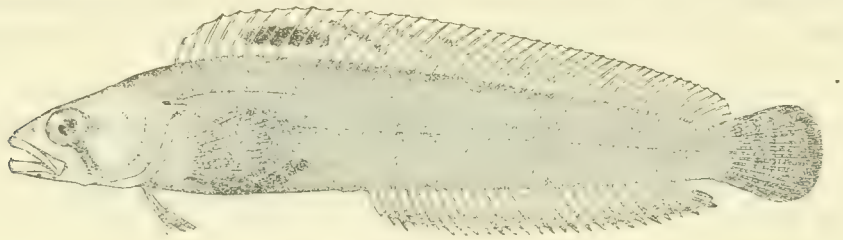

FIG. 184.—Radiated shanny (*Ulvaria subbifurcata*)

(43 or 44 dorsal spines), and especially by the much wider gill openings, which extend forward under the throat, whereas they are confined to the sides in the rock eel. The outline of the edge of the gill cover, with its upper corner terminating in a rounded fleshy flap concealing a sharp angle, is likewise diagnostic, for it is rounded in all other Gulf of Maine blennies. The relationship of dorsal and anal fins to the caudal is an equally useful field mark, the former being practically continuous with the caudal, but the anal separated from it by a definite, if short, space, made obvious by the abrupt rear angle of the fin. The pectoral is much larger than that of the rock eel, evenly rounded in outline, and reaches back about to the eighth dorsal spine. The caudal is evenly rounded and the anal is slightly more than half as long as the dorsal.

Color.—The most distinctive feature of the color pattern—one which marks this species among local blennies—is the presence of a large oval dusky blotch on the dorsal fin extending from the fifth or sixth to the eighth or tenth spine.[25] The back and upper sides are dull brown obscurely barred or blotched alternately with paler and darker, and the belly pale brownish (described also as yellowish

[23] Smitt. Scandinavian Fishes, 1892, p. 230.

[24] Based on three specimens from Grand Manan, the largest 5⅜ inches long.

[25] Only to the eighth in such specimens as we have seen.

white). The caudal is crossbarred with 3 or 4 series of dark dots and the dorsal with many tiny dark dots besides the blotch just mentioned. The sides of the head are described as marked with a dark bar running obliquely downward and backward from the eye, but this is not visible in the preserved specimens we have examined.

Size.—The largest one we have seen or found record of is 5⅜ inches long, but the maximum size may well be larger.

General range.—So far this fish is known only off the boreal coasts of eastern North America from the Gulf of St. Lawrence to Cape Cod, and there are few records of it.

Occurrence in the Gulf of Maine.—This shanny, first described by Storer (1853–1867, p. 93), who saw one "found at an unusually low tide among the seaweed at Nahant (in Massachusetts Bay) in 1838," was long supposed to be very rare and is so described by Jordan and Evermann as recently as 1898, but it has since proved to be common in the Bay of Fundy [26] among seaweed on rocky shores, a number having been taken both at Campobello Island and at Grand Manan, and one in the mouth of the St. Croix River, as Doctor Huntsman records in his notes (p. 9). He also reports it from St. Mary Bay on the Nova Scotia shore, while we have seen examples taken many years ago at Grand Manan. It has likewise been reported at Matinicus Rock and in Casco Bay on the coast of Maine, while we trawled one near Seguin Island and another in Massachusetts Bay, in 27 and 25 fathoms, respectively, on the *Grampus* in 1912, and caught its larvæ in tow nets near Seal Island (Nova Scotia), in the Grand Manan Channel, at the mouth of Casco Bay, near Cape Porpoise, off the Isles of Shoals, near Cape Ann, and in Massachusetts Bay. All this suggests that it is widespread in the coastal zone of the Gulf, but apparently more plentiful in the northeast than in the southwest part, which suggests a preference for comparatively low temperatures.

Habits.—Nothing is known of the mode of life of this shanny except that it lives among seaweed and stones from low tide mark down at least to 30 fathoms, and very likely much deeper. It is a bottom fish like other blennies and, as Doctor Huntsman writes in his notes, "is found under stones near low tide mark" with the rock eel, but far less abundantly and only on the more exposed shores. Cornish [27] likewise describes it as taken under stones on the beach, as well as in the dredge and trawl in 6 to 30 fathoms at Canso, Nova Scotia.

The eggs have never been seen, but the fact that we have taken larvæ as small as 8 to 11 mm. in June, July, and October [28] points to a breeding season lasting from late spring throughout the summer (supposing our identification to be correct).

[26] Huntsman, 1922a, p. 18.

[27] Further Contributions to Canadian Biology, 1902–1905 (1907), p. 87. *In* 39th Annual Report of the Department of Marine and Fisheries (of Canada), 1906, Fisheries Branch.

[28] These larvæ are listed in Bulletin of the Museum of Comparative Zoology at Harvard College, Vol. LVIII, No. 2, 1914, p. 109; and Vol. LIX, 1917, p. 273.

THE WRYMOUTHS. FAMILY CRYPTACANTHODIDÆ

The wrymouths are slender fishes of eel-like form, close relatives of the blennies but much larger. Like the latter they have a long dorsal fin, spiny throughout its length, but the demarcation between dorsal, caudal, and anal fins is so vague that they can be described as continuous. There are no ventral fins and the mouth is so oblique that it is nearly vertical. Only three species are known—all North American—of which the Gulf of Maine harbors one.

142. **Wrymouth** (*Cryptacanthodes maculatus* Storer)

CONGO EEL; BASTARD CUSK; GHOSTFISH

Jordan and Evermann, 1896–1900, p. 2443.

Description.—The wrymouth is eel-like in form, about thirteen times as long as deep but much compressed, and, eel-like, it lacks ventral fins; but its dorsal fin (which extends from just behind the pectoral back to the caudal) is spiny (about 73 spines) for its whole length like that of its close relatives, the blennies, and, just

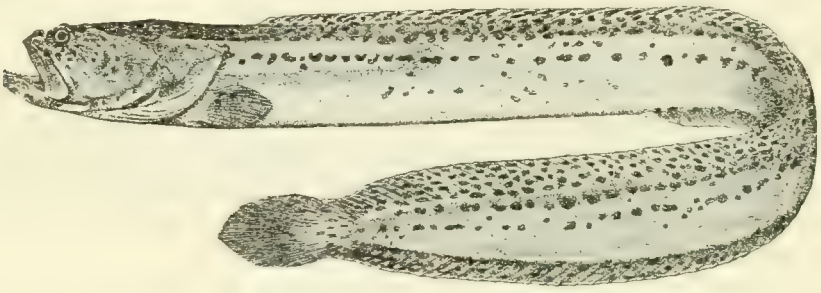

FIG. 185.—Wrymouth (*Cryptacanthodes maculatus*)

as in some of the latter, there is no definite demarcation between dorsal, caudal, and anal (about 50 rays), the one merging into the other to form a continuous fin with no interspaces. However, the absence of ventral fins marks it off from all of our local blennies, and its peculiar profile is an equally useful field mark, the head being flat-topped, the eyes set high up in very prominent orbits, and the mouth strongly oblique with the heavy lower jaw lending the face a "bull-dog" expression when the mouth is closed. The wide gill openings, running forward under the throat, the small size and rounded outline of the pectorals, the fact that both dorsal and anal are low (less than half as high as the body is deep) and of even height throughout most of their length, with the latter only about half as long as the former, and that the caudal is oval in outline, are also diagnostic.

Color.—Described (and the few preserved specimens we have seen correspond with this) as of varying shades of reddish brown with the upper sides with two or three irregular rows of small darker brown spots running from head to tail, the top of the head as thickly speckled, the vertical fins as spotted with similar but smaller dots, and the belly as grayish white. Occasionally spotless specimens have been seen.

Size.—Maximum length about 3 feet.

General range.—Coast of North America from Labrador to Long Island Sound.

Occurrence in the Gulf of Maine.—Published records locate this fish in the Bay of Fundy, at Eastport, in Casco Bay, at Portland, in the mouth of the Piscataqua River, at Gloucester, in Marblehead Harbor, at Swampscott, Nahant, Dorchester in Boston Harbor,[29] and in the outer waters of Massachusetts Bay, localities sufficiently scattered to show that it is to be found all along the coasts of the Gulf. However, it seems to be rare, or at least very local, everywhere. We have neither caught the adult nor have we seen it brought in by fishing boats. In fact, few of the fishermen of whom we have inquired have been aware of its existence, a fact no doubt associated with its burrowing habit; but in May, 1915, and March and April, 1920, we towed its late larvæ and fry (a total of 11 specimens ranging in length from 18 to 40 mm.) off Boston Harbor in Massachusetts Bay, near Mount Desert Island, over Jeffrey Bank off Penobscot Bay, in the trough near the Isles of Shoals, in the western basin a few miles west of Cashes Ledge, and in the deep basin off Machias, Me.

Habits.—Very little was known of its habits, except that it was a bottom fish living from the intertidal zone down to considerable depths (where it is sometimes taken on line trawls in the Bay of Fundy), until recently, but in 1910 and again in 1920 Willey and Huntsman (1921, p. 4) found fullgrown wrymouths living in burrows in the mud on the flats at the mouth of the Magaguadavic River, a tributary of Passamaquoddy Bay. These burrows, to quote from their account, "were found in very soft mud from the lower part of the Fucus zone downward; that is, as far up as 4 feet above low-water mark," and "each system of burrows, inhabited by only one fish, consisted of branching tunnels about 5 cm. in diameter and from 3 to 8 cm. below the surface," originating from a more or less centrally placed mound in which was the main entrance, with other smaller openings along the tunnels and at their terminations.

It seems that the burrowing instinct is strong, for one fish kept in a tank constantly inhabited a piece of hard rubber tubing. Hence it is probable that wrymouths in other parts of the Gulf likewise live in burrows or perhaps under stones, and apparently they are as apt to be inshore in shoal water in winter as in summer, for one was speared in Marblehead Harbor in December many years ago.[30]

Food.—Huntsman and Willey found "beach fleas" or "sand-hoppers" (Gammarus), shrimps (Crago), and fragments of winter flounders in several wrymouths which they opened, and the one kept in captivity readily ate sand-hoppers, hermit crabs, small herring, and mollusks such as limpets, periwinkles, whelks, clams, and mussels. Apparently it located food as much by sight as by smell.[31]

Breeding habits.—Ripe wrymouths are yet to be seen; but the presence of the larvæ early in spring in Passamaquoddy Bay, as reported by Huntsman, with the seasonal occurrence of the fry just mentioned, proves it a winter spawner in the Gulf of Maine, though it may breed later in the Gulf of St. Lawrence, for

[29] A specimen given Storer by Dr. Henry Bryant.

[30] Putnam, 1874, pp. 11–13.

[31] Willey and Huntsman (1921) also give interesting data on its respiration and response to various stimuli.

Dannevig[32] records a young wrymouth only 38 mm. long taken there as late as June 10. The localities where the young fish have been taken (p. 369) suggest that wrymouths spawn all around the coast line of the Gulf of Maine and wherever they occur on the offshore banks.

Neither the eggs nor the early larval stages are known, but by the time the young have grown to a length of 21 to 22 mm., with the dorsal and anal fin rays visible, they show the long vertical fins and lack of ventral fins diagnostic of the species, though they are relatively much less elongate than the adult, their caudal fins larger and square instead of rounded, while their mouths are still nearly horizontal. The pigmentation of the fry is likewise extremely characteristic, the upper sides from the eye back to the caudal fin being thickly speckled with dark brown dots, which become sparser on the lower sides. This color pattern, developed in larvæ as small as 18 mm. (that is, even before the dorsal and anal fin rays are visible), makes it easy to distinguish young wrymouths from any of the blenny tribe, in which the abdominal region and the ventral side of the trunk, but not the back, are pigmented. Young wrymouths are likewise deeper bodied than rock-eel or blenny larvæ and are further advanced in development at equal lengths.

THE WOLFFISHES. FAMILY ANARHICHADIDÆ

The wolffishes are closely allied to the blennies and like the latter have a single long spiny dorsal fin running the whole length of the back from the nape; but the presence of large molar teeth and canine tusks, with the total lack of ventral fins and the fact that all but the last 10 or 12 dorsal fin spines are soft and flexible at the tips, justify a separate family for their reception. They are much larger fish than any of the blenny tribe, also. Two species occur in the Gulf of Maine—one common and the other very rare.

KEY TO GULF OF MAINE WOLFFISHES

1. Plain colored or dark barred and blotched but not definitely black-spotted; the central band of molars in the roof of the mouth is shorter than the bands flanking it_____ Common wolffish, p. 370

   Definitely black spotted on a pale ground; the bands of molars in the roof of the mouth are all of equal length _____ Spotted wolffish, p. 375

143. **Wolffish** (*Anarhichas lupus* Linnæus)

CATFISH [33]

Jordan and Evermann, 1896–1900, p. 2446.

Description.—The wolffish suggests a huge blenny in its general make-up, but only the last 10 or 12 spines of its dorsal fin are stiff to the tips, those farther forward being flexible at the outer ends. There are no ventral fins. The mouth is armed with a set of teeth more formidable than those of any other Gulf of Maine fishes except the sharks. These teeth are arranged as follows: In the upper jaw there is a row of about 6 very large, stout, conical canine tusks with a cluster of 5 or 6

[32] Canadian Fisheries Expedition, 1914–1915 (1919) p. 16. On pl. 2, fig. 10, he gives an excellent figure of this specimen.

[33] Whitefish in the markets.

smaller canines behind them; the roof of the mouth back of the latter is armed with three series of crushing teeth, the central series consisting of a double row of about 4 pairs of large rounded molars united into a solid plate, and each of the outer series consisting of two alternating rows of blunt conical teeth. The lower jaw bears 4 to 6 large tusks in front, behind which there are two longitudinal diverging rows of rounded molars, and the throat is also furnished with small

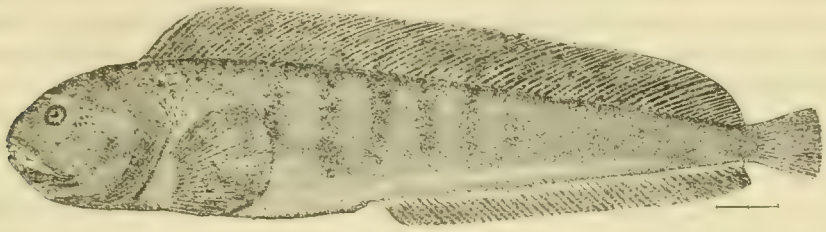

FIG 186.—Adult

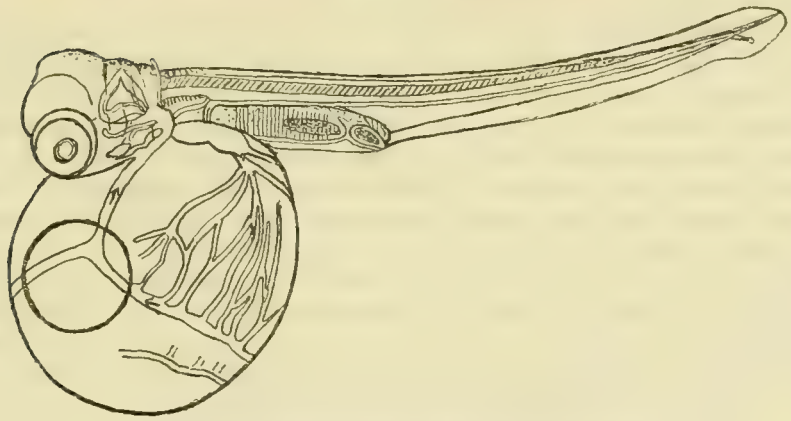

FIG. 187.—Larva (European), just hatched. After Ehrenbaum

FIG. 188.—Larva, 21.5 millimeters

WOLFFISH (*Anarhichas lupus*)

scattered teeth. The great projecting tusks, rounded nose, and small eyes give the wolf a singularly savage aspect. The body is deepest close behind the head, tapering back to a slender caudal peduncle and small weak tail. The dorsal fin—about half as high as the head is long, and uniform in height except for its rounded corners (69 to 77 spines)—runs from the nape of the neck to the base of the caudal.

The anal (42 to 48 rays) is only about half as high and slightly more than half as long as the dorsal and its rear corner is angular. The pectorals are large and rounded and the caudal slightly convex in outline.

Color.—Wolffishes are always dull colored but vary widely in tint. The upper parts and dorsal fins of those taken off the Massachusetts coast have been described as purplish brown and we have seen them of this tint, but according to Mr. Clapp fish caught on Georges Bank are invariably dull olive green, while in other seas they are described as purplish, brownish, or bluish gray, or as slate colored. No doubt the color of the wolf, like that of many other ground fish, varies with that of its surroundings, purplish and brown tints ruling among red seaweeds and olive gray on clean bottoms. Whatever its tint, its sides are transversely barred with a variable number (usually 10 or more) of irregular and broken darker bands or blotches or scattered spots that extend out on the dorsal fin. The throat and the belly back to the vent are dirty white tinged with the general ground tint of the upper parts. Wolffish fade so soon after they are caught that those seen in the markets are usually much paler than they are in life.

Size.—A length of 5 feet and a weight of approximately 30 pounds seems about the maximum in Gulf of Maine waters, and one more than 4 feet long is seldom seen, the larger fish caught and brought in not running over 3 feet. European authors, it is true, speak of wolffish of 6 feet and even longer, but they average only about 2 feet in Scandinavian waters,[34] hardly as large as in the Gulf of Maine.

General range.—Both sides of the North Atlantic, north to Davis Strait and south regularly to Cape Cod, more rarely to southern New England, and exceptionally to New Jersey in American waters.

Occurrence in the Gulf of Maine.—Although the wolffish has been recorded from but few definite stations [35] in scientific literature, it is actually a fairly common fish in the Gulf, though hardly to be described as abundant, and is to be caught very generally on suitable bottom in all parts of the Gulf though nowhere in any great numbers. Thus it is taken regularly at the mouth of the Bay of Fundy (not listed in the Canadian fishery statistics, however) and about Grand Manan. A few are yearly brought in from off Mount Desert and from the other small fishing grounds between Eastport and Penobscot Bay, larger numbers are taken off the islands from Penobscot Bay to Casco Bay (the catch by the shore fishermen of this part of the coast aggregated nearly 23,000 pounds in 1902), but the most productive grounds for Maine are off Casco Bay, whence no less than 29,829 pounds were brought in by small boats in 1919, 17,700 pounds in 1905, and 146,700 pounds in 1902. More or less catfish, as most fishermen call them, are also caught on hand and trawl lines along the coast southward to Massachusetts Bay. In the year 1905, for example, small-boat fishermen landed 16,000 pounds between Cape Elizabeth and the New Hampshire line, and over 37,000 pounds in Essex County, Mass., most of the latter coming from Jeffreys Ledge and Stellwagen Bank and from the deeper rocky spots near Gloucester and Nahant, grounds where fishermen report them as fairly plentiful but running smaller than on Georges Bank.

[34] Smitt. Scandinavian Fishes, 1892, p. 232.

[35] The North Channel, off Cape Sable, in St. Mary Bay, at Grand Manan, at Campobello, mouth of the Bay of Fundy, Eastport, Mussel Ridge Channel, Casco Bay, Ipswich Bay, Annisquam, off Gloucester, Massachusetts Bay, North Truro, Nantucket Shoals, and Georges Bank.

The catch from any given region varies widely from year to year. For example, the landings in Barnstable County, Mass., rose from less than 300 pounds in 1905 to more than 13,000 in 1919, whereas less than half as many fish were caught off Gloucester during the latter year as in the former. The total coastwise catch for Massachusetts and Maine combined shrank by over 50 per cent from 1902 to 1919 and 1920, either because the fish have actually diminished in number on the inshore grounds, or because the fishermen have resorted to localities less productive of this particular species, which is a more likely explanation since the wolffish is very local in its occurrence.

The wolffish is general on Georges Bank (probably on the other offshore banks also), where it is caught regularly both by otter trawlers and by hand-line fishermen, it being usual for vessels of these classes to bring in anywhere from 1 to 40 or 50 per trip. Although it is a solitary fish, one living here and one there, and is nowhere abundant in the sense that the term is applied to cod, haddock, pollock, or our other important commercial fishes, these offshore grounds yielded about three times as much weight of wolffish as did those inshore in 1919. We may add, to illustrate the abundance of the stock of this species as compared with other fishes, that the total catch in the Gulf of Maine in that year was between 300,000 and 400,000 pounds.[36]

The depth zone occupied by the wolffish at one time or another extends from a fathom or so below tide mark down to 85 fathoms at least and very likely deeper. It has been reported in tide pools at Eastport, but we have never heard of it in such situations or at low-water mark anywhere else in the Gulf, nor does it run up estuaries. Probably most of the local stock lives in depths of 10 to 40 fathoms. It is a ground fish, always caught on hard bottom, never on mud, a weak swimmer, moving by sinuous side to side undulations like a blenny or an eel, and probably it spends most of its life hidden among seaweed or rocks or nosing about such surroundings for food. As it passes through only a brief pelagic stage when young (p. 375), the wolf may be classed as a comparatively stationary fish, with much less interchange from one locality to another than is the case with cod or haddock.

Although there is no reason to suppose the wolffish ever attacks other fish, it snaps like a bulldog and with good aim at anything in its way—one's hands, an oar, or at other fish among which it is thrown when hauled out of the water—and so serious a bite can it inflict that fishermen hasten to knock it on the head as soon as it is brought aboard. Goode (et al., 1884), indeed, remarks that it has been known to attack furiously persons wading among the rock pools of Eastport, Me., but we have never heard of such an occurrence of late years.

The wolf is resident wherever found, to be caught throughout the year. For example, about as many are brought in from Georges Bank in one month as in another.

Food.—The diet of this fish consists wholly of hard-shelled mollusks, crustaceans, and echinoderms. So far as we can learn fish have never been found in the stomach of a wolffish and the old myth that it is a terror to other fishes has been exploded long since. Mr. Clapp found that the 50 or 60 fish that he opened on Georges Bank had all eaten large whelks (Buccinum), cockles (Lunatia, Chryso-

[36] The amount can not be stated more exactly for want of statistics for Nova Scotia and the Bay of Fundy.

domus, and Fusus), sea clams (Mactra), and other shells, which the wolffish crushes easily in its vicelike molars. Sometimes, however, these mollusks are swallowed whole. In north European waters wolffish are said to subsist largely on mussels, and one taken and examined by Vinal Edwards at Woods Hole was full of these; but although mussels are plentiful on Georges Bank none were found in stomachs of the fish caught there, which points to a definite preference for the other shellfish just mentioned. The wolf is also known to feed on large hermit crabs, ordinary crabs and other crustaceans, starfish, and sea urchins, a quart of the latter having been taken from one caught at Eastport;[37] and Mr. Clapp's observations that every one he has opened contained food of some sort is good evidence of its constant search for anything edible. With such a diet it is not surprising that wolffish are more often caught on hand lines baited with cockles or clams than on line trawls, which are usually baited with herring.

Breeding habits.—The breeding habits of the wolffish have not been followed on this side of the Atlantic. In north European waters it spawns chiefly from November until January,[38] and apparently the breeding season is about the same in the Gulf of Maine, for we have taken larvæ of 20 to 22 mm. (fig. 188)—that is, 2 to 3 months old from the time the eggs were deposited—as early as January 30 in 1913, and as late as March 4 in 1920.

The eggs, 5.5 to 6 mm. in diameter, among the largest fish eggs known, yellowish, opaque, and with an oil globule of 1.75 mm., are laid on the bottom in shoal water where they stick together in large loose clumps among weeds, stones, etc. The fish have been described as making an annual shoreward journey for spawning purposes, but there is little evidence of this. The precise duration of incubation is yet to be learned. Probably it is long, as with most fishes laying eggs that lie on bottom.

The slender transparent larvæ are about half an inch (12 mm.) long at hatching, with an enormous baglike yolk sac inclosed in a net of highly developed blood vessels (see fig. 187, p. 371), thus remotely suggesting salmon or trout larvæ in appearance. This yolk gradually shrinks as the larva grows, but it persists much longer than in species producing buoyant eggs. Wolffish hatched by McIntosh and Prince in the aquarium at St. Andrews, Scotland, did not absorb the yolk sac wholly until about 3½ months old and upward of 20 mm. long, but in natural surroundings larvæ as small as 17 mm. have been found free of yolk, nor is any trace of it visible in the larvæ of 21 mm. and upward which we have towed in the Gulf of Maine. Larvæ of 20 to 22 mm. show the dorsal and ventral spines and fin rays in their final number, but the large head, enormous eyes, and tiny teeth, and the fact that there is no definite separation between the anal and dorsal fins and the caudal, give the young fishes an aspect very different from that of the adult until they are 1¼ to 1¾ inches long. In life the wolf is silvery on the sides at this stage, but this metallic hue fades after preservation, leaving only the dark brown pigment granules with which the sides are thickly dotted. The largest fry we have seen (44 mm. long) show similar but somewhat paler pigmentation.

[37] Verrill, 1871, p. 400.

[38] It was formerly thought to spawn in spring, but McIntosh and Prince (Transactions, Royal Society of Edinburgh, Vol. XXXV, Part III (No. 19), 1890), to whom we owe all that is known of its early larval development, proved it an autumn and winter spawner both by examination of its ovaries and by the discovery of its eggs.

When first hatched the larvæ lie on bottom, resting on the yolk like young trout or salmon, becoming more active as the yolk is absorbed; but it is not until the latter is considerably reduced in size (that is, until several weeks after hatching) that they swim much, and they do no more than dart upward for a few inches and then settle back again until a month or more old. Thus the wolffish spends the early part of its development period close to bottom instead of drifting at the mercy of tide and current, as do all the fishes that produce buoyant eggs. While some of the older larvæ and young fry adopt a pelagic habit for a time after the yolk is absorbed (for we took some 20 specimens of various lengths from 21 to 44 mm., in tow nets during March and April, 1920), it seems that they seldom rise to the uppermost water layers, for only two of the eight hauls were at the surface, the others being at depths of 30 to 60 fathoms; and as fry no larger than this have been trawled on bottom in European waters, some of them may never leave the ground at all. It follows, then, that the wolffish probably is not subject to the long involuntary migrations carried out by most members of the cod and flatfish tribes, but that it passes through its entire larval stage near where it is hatched, and hence that the localities where the young are taken are evidence of local spawning. On this basis it seems that the wolffish breeds generally in the eastern as well as in the western part of the Gulf, for we have taken its larvæ in the North Channel, near Seal Island (Nova Scotia), on and off the slope of German Bank, off Lurcher Shoal, in the deep off Machias (Maine), on Jeffrey Bank (off Penobscot Bay), and in Massachusetts Bay a few miles off Gloucester. The brevity of the pelagic stage also implies that it is on local reproduction that the stock depends for its maintenance in any given locality.

In Scottish waters wolffish fry, no doubt hatched the preceding autumn, have been taken as long as 5 to 6 inches in July, and 7 to 8 inches in August, pointing to a rapid rate of growth for the first summer. Nothing is known of the later growth.

Commercial importance.—Although so repellant in appearance that the market demand for it is of comparatively recent growth, the wolf is an excellent table fish, selling readily as "catfish" or as "ocean whitefish."

143. **Spotted wolffish** (*Anarhichas minor* Olafsen)

SPOTTED CATFISH

Jordan and Evermann, 1896–1900, p. 2446.

Description.—This species closely resembles the common wolffish in its general form and in the arrangement of its fins, the chief difference between the two being that while the central ("vomerine") band of teeth on the roof of the mouth is shorter than the band on either side ("palatine") in the common wolffish, these bands are of about equal length in the spotted wolffish, while its teeth are described (we have never seen it) as red, not white. Furthermore the dorsal fin is continuous with the caudal, although with its last 3 to 6 spines much shorter than those further forward, whereas the two fins are quite separate in the common wolf. Color,

however, is its best field mark, the pale olive or chocolate[39] upper parts of the present species, together with the dorsal and caudal fins, being thickly sprinkled with blackish brown spots of varying size and irregular shape.

Size.—Notwithstanding its Latin name this is fully as large a fish as the common wolffish, said to grow to a length of 6 feet.

General range.—Chiefly north of the Arctic Circle, south to Norway on the eastern side of the North Atlantic and to Massachusetts Bay on the western side.

Occurrence in the Gulf of Maine.—Goode and Bean's (1879, p. 11) statement that "the Fish Commission has specimens from off the mouth of Gloucester Harbor and from Eastport, Me.," long remained the only notice of this northern fish in the Gulf of Maine, but Walter Rich, of the U. S. Bureau of Fisheries, has recently obtained a specimen taken in 35 fathoms off Cape Elizabeth and now in the collection of the Portland Society of Natural History. Shore fishermen of whom we have inquired have either never seen it or fail to discriminate between it and the common wolffish (this is hardly likely, so striking is its color pattern), though vessel fishermen are familiar with it in more northern waters. Nor did Huntsman hear of it in the Bay of Fundy. In short, this side of Cape Sable it is only an accidental waif from its Arctic home, one to be watched for but hardly expected.[40]

Habits.—Very little is known of its habits except that its diet is much the same as that of its more common relative, and it is said to keep to rather deeper waters, having been caught as deep as 200 to 240 fathoms off Banquereau.[41]

THE EELPOUTS. FAMILY ZOARCIDÆ

The eelpouts are elongate eel-like fishes with the anal fin continuous with the caudal. In most members of the family the dorsal joins the caudal equally, making one continuous fin extending around the tip of the tail, but in the only common Gulf of Maine species the rear portion of the dorsal is so low that there is apparently a bare space between it and the caudal. Eelpouts are readily separable from the true eels by the presence of ventral fins, small but unmistakable, situated slightly in advance of the pectorals. Their closest affinities among Gulf of Maine fishes are with the blennies (p. 359), the wolffishes (p. 370), and the wrymouths (p. 368), but they are easily separable from the blennies and wrymouths by the fact that at least the major part of the dorsal fin is soft rayed, not spiny, and from the wolffish by their more slender form and smaller teeth.

KEY TO GULF OF MAINE EELPOUTS

1. The dorsal fin is apparently separated from the caudal by a considerable gap..Eelpout, p. 378
   Dorsal, caudal, and anal fins together form one uninterrupted fin..... 2
2. Extremely elongate, at least 12 times as long as deep.....Wolf eel, p. 382
   Only about 8 times as long as deep.....Arctic eelpout, p. 383

[39] The general ground tint has been variously described.

[40] Goode's statement that it has been seen in the Bay of Fundy (Goode, et al., 1884) apparently refers to the Eastport record just mentioned.

[41] Bean, 1881, p. 82.

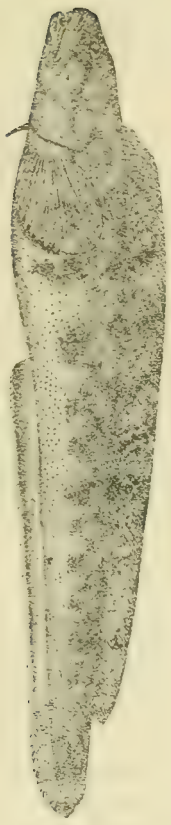

FIG. 190.—Eelpout (*Zoarces anguillaris*)

FIG. 189.—Spotted wolffish (*Anarhichas minor*)

145. **Eelpout** (*Zoarces anguillaris* Peck)

YOWLER; CONGER EEL; CONGO EEL; MUTTONFISH; LAMPER EEL; LING

Jordan and Evermann, 1896–1900, p. 2457.

Description.—The eelpout is blennylike or eel-like in form, its body about eight times as long as deep, moderately compressed but noticeably sway bellied, and tapering backward from the pectorals, where it is deepest, to a pointed tail. It is very soft, its scales very small, and its skin as slimy as an eel. Its ventrals are very small like those of the rock eel (p. 359), and situated well forward of the pectorals. The most useful field mark for the identification of the eelpout among the several eel-like fishes with which it might be confused are its vertical fins. Its anal is continuous with the caudal and with no trace of a notch of demarcation between the two, just as is the case with the true eels. In reality this is true of the dorsal fin also, but a few of the dorsal rays near the rear end of the fin are so short as to be hardly visible, so that *apparently* there is a considerable free interspace between the dorsal and caudal fins. Furthermore, these short rays are spiny instead of soft like all the others. The dorsal fin runs from the nape back along the whole length of the trunk and consists of about 128 rays—first about 95 soft rays and then the 16 to 18 short spines followed by about 17 more soft rays. The anal (about 105 soft rays) originates slightly in front of the midlength of the fish. Except as just noted, both the dorsal and the anal are of nearly even height, but the former is nearly twice as high as the latter. The pectoral fins are large and rounded like those of the wolffish. The mouth is wide, gaping back of the small eye, and set so low that it gives the profile a diagnostic aspect, with thick and fleshy lips. Both jaws are armed with two series of strong, blunt conical teeth, largest in front, but the mouth lacks the crushing teeth so characteristic of the wolffish.

Color.—Although this fish has usually been described as reddish brown mottled with olive, or as salmon colored, most of those we have seen caught—a fair number—have been of some shade of muddy yellow, paler or darker, some with brownish, some with salmon, and some with orange tinge, while a few have been pure olive green; and since fishermen usually describe them as "yellow," this is evidently the prevailing hue in the offshore parts of the Gulf. Other eelpouts that we have caught inshore along the coast of Maine, however, have shown yellow only on the margins of the fins, particularly the lower edge of the pectorals, the general ground tint of sides and back ranging from pale gray, sometimes with purplish tinge, to dull brown or dark dusky olive below as well as above. One of a pair caught side by side in Northeast Harbor, Mount Desert, was pale grayish white below while the other was amethyst pink on the belly and lower side of the head. Whatever the ground tint, the sides are dotted with small dark spots clustered in irregular crossbars and extending out on the dorsal fin.

Size.—The eelpout is said to reach a length of 3½ feet and a weight of 12 pounds, but most of those caught are much smaller. Two feet 10 inches was the longest we have seen, and 2 feet is a large one, with 1½ feet in length a fair average for adults. Fish measured by Clemens and Clemens (1921) weighed approxi-

mately ¼ pound at 12½ inches, ½ pound at 15 inches, ¾ pound at 17 inches, 1 pound at 18 inches, 1½ pounds at 19 inches, 2 pounds at 21 inches, 3 pounds at 24 inches, and 4 pounds at 27 inches.

General range.—Coast of North America from the Straits of Belle Isle and Gulf of St. Lawrence south to Delaware.[42] The eelpout of North Europe (*Zoarces viviparus* Linnæus), a very close relative, is distinguishable only by fewer fin rays (about 100 dorsal rays and 6 to 10 spines; 80 to 89 anal rays).

Occurrence in the Gulf of Maine.—This fish, known as "yowler" by vessel fishermen, "ling" on Cape Cod, and "lamper," "conger," or "congo eel" in Maine, is familiar in the Gulf and very abundant locally, both near shore in moderate depths of water, and on the outer banks. It is common off western Nova Scotia, in the Bay of Fundy, all along the coasts of Maine and Massachusetts, and is taken in considerable numbers on Georges Bank both by otter trawlers and by line fishermen.[43]

There seems to be a wide difference in the depth zone frequented by the eelpout in different parts of the Gulf. In the Bay of Fundy some of them run up into shoal water in summer and young ones are to be found under stones and among seaweed between tide marks. Similarly, as we can bear witness, one is always apt to catch several in a half day's flounder fishing in 1 to 3 fathoms in Penobscot Bay or in Northeast Harbor, and this probably applies to bays and harbors all along the coast of Maine east of Cape Elizabeth. We have never seen one taken in less than 10 fathoms of water in the Massachusetts Bay region, where most fishermen speak of it as a comparatively deep-water fish, though it has been recorded from Gloucester Harbor. On the offshore banks eelpouts live at 20 to 50 fathoms, and, taking the Gulf as a whole, the majority of the stock of eelpouts would probably be found between 10 and 45 fathoms. We can not state the lower depth limit. Probably, however, few occur deeper than 60 or 70 fathoms, for we have not heard of them on the soft slimy ooze in the bottoms of the deeper basins.

Eelpouts seek different types of bottom in different localities. They are hardly ever caught on the good fishing grounds—that is, stony or gravelly bottoms or about ledges—in Massachusetts Bay, but if the line trawl chances to run off these the portion resting on the soft sticky mud that floors the deeper parts of the bay often brings in eelpouts and nothing else except an odd hake, and so frequently does this happen that such places are commonly termed "yowler bottom." We have trawled them on rather sticky sand in Ispwich Bay (22 fathoms), however, among a good catch of hake and plaice, likewise on broken bottom at the mouth of Casco Bay, and on pebbles and mud in Penobscot Bay. East of the latter they are commonly caught on stony ground, while Huntsman describes them as taken on hard bottom in the Bay of Fundy.

The eelpout, broadly speaking, is a resident fish wherever found, its only migrations taking the form of on and offshore movements, and even these are

[42] There is a doubtful record for North Carolina (Smith, North Carolina Geological and Economic Survey, Vol. II, 1907, p. 379).

[43] Clemens and Clemens (1921, p. 69) give a general account of the life history of the eelpout in the Bay of Fundy and a list of the localities whence it has been recorded.

irregular. In the Bay of Fundy, Huntsman describes them as working inshore in spring, moving out again into deeper water in October or early November, and as absent from the estuaries from January to April. Their abundance in Penobscot Bay in midsummer suggests that some of them perform a similar on and offshore migration there. However, this probably does not apply to the coast south of Cape Elizabeth and certainly not to Massachusetts Bay, where as careful an observer as Goode (et al., 1884) long ago described them as coming most often into shoal water in winter. Probably the truth is that their presence or absence close inshore, in any particular locality and season, depends not only on the local supply of food but on temperature, for the upper 10 to 15 fathoms in the southern part of the Gulf as a whole may well be too warm for them in summer, and estuaries particularly subject to severe chilling too cold in winter.

Habits.—The eelpout is a ground fish, and judging from its habits in aquaria probably spends most of its life hiding among weeds and stones. Being of no value little attention would be paid to it did it not make a nuisance of itself by snarling the trawl lines. It is almost incredible to what a hopeless tangle of cord, fish, and slime a few "yowlers" can reduce many fathoms of line.

Food.[44]—The American eelpout feeds on shelled mollusks, both bivalve and univalve, crustaceans large and small, echinoderms and other invertebrates, and less often on fish. The Bay of Fundy fish opened by Clemens and Clemens (1921), who give a considerable list, had dieted chiefly on the two common mussels, Mytilus and Modiolaria, whelks (Buccinum), periwinkles (Littorina), scallops, sea urchins, brittle stars, and barnacles, while various other bottom-living mollusks have been found in them and also an occasional fish (smelt and others unrecognizable). Since they bite fish (herring, etc.) as greedily as clam or cockle bait, and take fish readily when kept in captivity, no doubt they eat fish when occasion offers, as their European relative does. A large specimen caught in Massachusetts Bay, January, 1924, was packed full of brittle stars (ophiurans), spider crabs, and small sea scallops (*Pecten magellanicus*).

Growth.—Clemens and Clemens estimated the ages of Bay of Fundy eelpouts from the annual rings on their otoliths, as follows:

Age	Length in inches	Age	Length in inches
First year	1.5 to 4	Tenth year	17.4 to 21.5
Second year	4.8 to 5.9	Eleventh year	18.2 to 22.4
Third year	7 to 8.4	Twelfth year	22.6 to 22.8
Fourth year	8.7 to 10.5	Thirteenth year	24
Fifth year	10.2 to 12.4	Fourteenth year	23.8
Sixth year	12.5 to 14	Fifteenth year	23.8
Seventh year	13.7 to 14	Sixteenth year	24 to 29
Eighth year	15 to 19	Seventeenth year	24.6 to 27.2
Ninth year	16.4 to 20	Nineteenth year	27

Although these estimates are only tentative for the larger specimens, few of which were examined, they show that this is a slow-growing but long-lived fish, most of those caught being 5 to 10 years old according to this schedule.

[44] Willey and Hunstman (1921, p. 6) relate some observations on the habits and reactions of one kept in an aquarium at St. Andrews.

Breeding habits.—Little is definitely known of the breeding habits of the American eelpout, no ripe specimens of either sex having been seen. Females with eggs in advanced stages of development, 4 to 5 mm. in diameter, have been taken about St. Andrews from May until July and in Massachusetts Bay in midsummer (for instance one in this state caught near Boston was brought in to the Museum of Comparative Zoology on August 10, 1922), and it was on the strength of females in this condition that Goode (et al., 1884) assumed July and August as the spawning season. However, the sexual condition of specimens caught in different months near St. Andrews, where no spent eelpouts were taken before October, coupled with the discovery of fry (one from the stomach of a sculpin) in April, convinced the authors just mentioned (and we believe correctly) that spawning takes place in autumn. They likewise suggest that their failure to find either males or females closely approaching sexual maturity at St. Andrews is evidence that the fish move offshore to spawn. This does not necessarily follow, however, because eelpouts, like many other fish, may cease feeding at this time, and hence the ripe fish might not be caught on hook and line no matter how plentiful they were. The fact that fish taken in summer differed widely in the state of development of their sexual products suggested to Clemens and Clemens that they do not breed every year, but it seems to us more probable that this is evidence simply of a protracted breeding period, some individuals ripening early in autumn, others perhaps not until winter.

The European eelpout (*Zoarces viviparus*) is viviparous, as its name suggests, but whether this is also true of the American fish is not known. However, the latter produces so many more eggs than the former (Clemens and Clemens counted 1,800 in a female of 3¾ pounds, as against 200 to 400 in the European fish) that if the eggs are not deposited before hatching the young must be liberated soon after and not retained within the oviducts of the mother until 40 to 50 mm. long, as is said to be the case with the European species.

The smallest fish with large eggs seen by Clemens and Clemens were 16 to 18 inches long, indicating that this species does not mature until about 8 years old, if their schedule of age and size (p. 380) be correct. The young of the American eelpout have not been described. Those of its European relative are not only very large when set free,[45] as just noted, and of adult form and structure, but some even mature their eggs shortly thereafter. They take to the bottom at once without passing through a pelagic stage, but it remains to be seen whether this applies equally to the American eelpout.

Commercial importance.—Although the eelpout is described as a very sweet fish (we have never eaten it) there is no regular market for it and the offshore fishermen throw away all they catch, but a few are brought in by the smaller boats and hawked on the streets of Boston.

[45] McIntosh (The Annals and Magazine of Natural History, Vol. XV, Fifth Series, 1885, p. 429). Stuhlmann (Abhandungen, naturwissenschaftlicher Verein, Hamburg, vol. 10, 1887, No. 12, pl. 4, fig. 87, 88).

146. **Wolf eel** (*Lycenchelys verrillii* Goode and Bean)

Jordan and Evermann, 1896–1900, p. 2470.

Description.—This fish is eel-like in form and resembles the eelpout in most respects, but is more slender (12 to 14 times as long as deep), and there is no separation, apparent or real, between dorsal, caudal, and anal fins, the one continuous vertical fin running along the back, around the tail, and forward on the lower surface to the vent. The dorsal fin not only originates farther back than in the eelpout (over the tip of the pectoral instead of in front of the base of the latter), but all the dorsal rays (about 92) are soft. Furthermore the anal (about 88 rays) extends relatively farther forward. The pectorals are rounded like those of the eelpout, the small ventrals similarly located well forward of the pectorals, and in small specimens the head resembles that of its relative in profile except for a somewhat wider mouth. Old males (fig. 191) "are transformed almost beyond specific recognition by an extraordinary development of the entire head in advance of the eyes. The snout becomes shovel-shaped, its length equal to two-fifths that of the head, while in the normal condition it is one-fourth." [46]

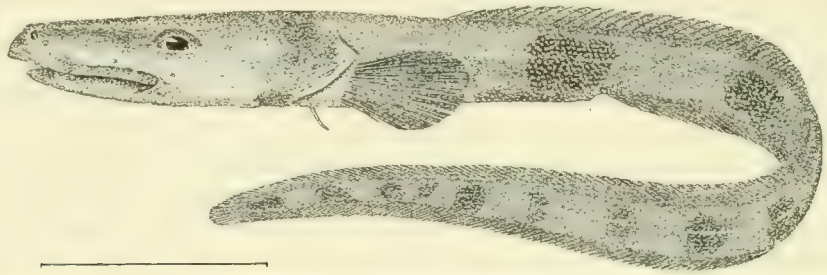

FIG. 191.—Wolf eel, male (*Lycenchelys verrillii*)

Color.—Described as light grayish brown above the lateral line, pearly white below, with livid blue belly, the sides marked with irregular brown patches bisected by the lateral line, and dotted with white above the latter. We have no color notes from life, but preserved specimens show these patches clearly.

Size.—Seven to ten inches long.

General range.—So far known only off the coasts of New England and Nova Scotia, in rather deep water.

Occurrence in the Gulf of Maine.—This is certainly a rare fish in the Gulf, a few specimens trawled off the mouth of Passamaquoddy Bay in 35 to 50 fathoms, one 4 inches long taken off Monhegan Island by the *Grampus* on August 2, 1912, in 60 fathoms, with several collected off Cape Ann in 75 to 110 fathoms, in the Western Basin in 115 fathoms, and off Cape Cod by the U. S. Fish Commission many years ago, being the only records in its inner waters. It has been trawled at many localities on the continental slope at 200 to 400 fathoms between longitudes 68° 22′ and 75° W., and probably it occurs all along this zone thence eastward, for it is known from the fishing banks off the outer coast of Nova Scotia, off Cape Negro, and off Halifax (90 to 101 fathoms).

[46] Goode and Bean, 1896, p. 310.

It is a bottom fish, living on mud or sand and confined to considerable depths of water. Normally 25 to 30 fathoms is its upper limit, but the fact that the *Grampus* specimen just mentioned was taken in a tow net, though close to bottom, proves that it sometimes rises from the ground.

Nothing is known of its life history or of its breeding habits.[47]

147. **Arctic eelpout** (*Lycodes reticulatus* Reinhardt)

Jordan and Evermann, 1896–1900, p. 2465.

Description.—This fish resembles the eelpout in its general appearance and in the arrangement of its fins. The readiest field mark for it is that the dorsal fin is not interrupted, but together with the caudal and anal forms one continuous fin extending around the tip of the tail, and that it originates behind the base of the pectoral instead of in front of it, while the fanlike pectoral fins are even larger, relatively, than those of the eelpout. Furthermore the upper jaw projects far beyond the lower, giving it a distinctive cast of countenance (compare fig. 192 with fig. 190). The most obvious difference between this Lycodes and the wolf eel (p. 382) is that the former is much the stouter and less elongate of the two, being only about 8 times as long as deep, whereas the wolf eel is 12 or 13 times as long; and the dorsal fin of *Lycodes reticulatus* originates farther forward—that is, close behind the base of the pectoral instead of over the tip of the latter.

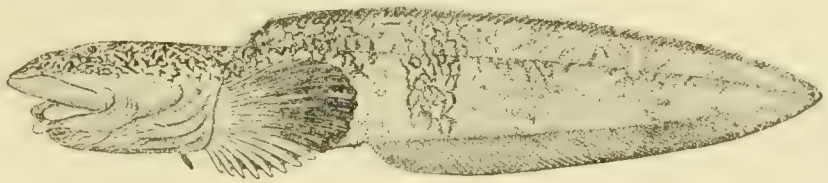

FIG. 192.—Arctic eelpout (*Lycodes reticulatus*)

Color.—Described as brownish, with a network of black lines on the head and several groups of such lines or solid dark bands on the body. The dorsal fin is dark edged. The young fry are marked with a series of large dark spots on the back and extending out on the dorsal fin.[48]

Size.—Maximum length about 22 inches.

General range.—Greenland and Spitzbergen and both sides of the North Atlantic. Off the American coast this Lycodes has been taken on the Grand Banks, on St. Pierre Bank, and off the slope of Banquereau Bank in depths of 82 to 300 fathoms; likewise in shoal water in Vineyard Sound and Narragansett Bay. As yet it has not been found within the limits of the Gulf of Maine, but it is to be expected there in view of its occurrence off southern New England.[49]

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[47] A closely allied deep-water species (*L. parillus* Goode and Bean) has been taken at numerous localities on the continental slope abreast of the Gulf and off southern New England in depths of 365 to 904 fathoms. It is separable from the wolf eel by its numerous fin rays (about 118 dorsal and 110 anal) and darker color. Goode and Bean (1896) describe and illustrate it.

[48] See Smitt (Scandinavian Fishes, 1892, p. 608) for the coloration of this genus in general.

[49] Two other species of Lycodes (*L. esmarki* Collett and *L. atlanticus* Jensen, described by Goode and Bean as *L. frigidus* Collett) have been trawled in considerable depths on the continental slope abreast of the Gulf of Maine or on both sides of it, but being deep-water forms they are not to be expected within our limits. For accounts of them and records of their occurrence in this general region we refer the reader to Goode and Bean (1896).

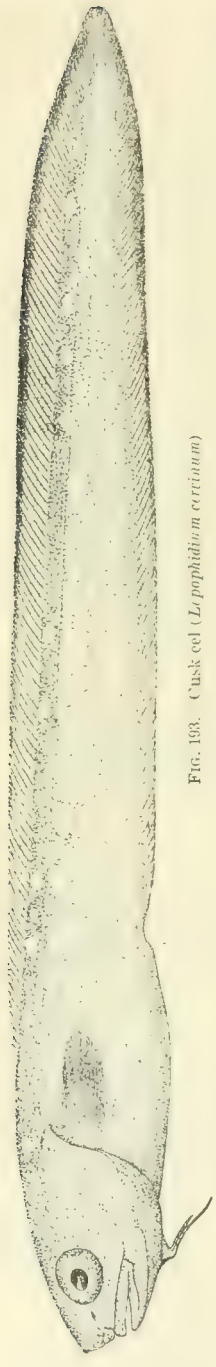

FIG. 193. Cusk eel (*Lepophidium cervinum*)

abits.—Little is known of its habits except that it is a ground fish, usually living in moderately deep water, and carnivorous, for worms, crustaceans, and small fish have been found in the stomachs of European specimens. In its turn it falls a prey to larger fishes and frequently to Greenland sharks.[50]

THE CUSK EELS. FAMILY OPHIDIIDÆ

148. **Cusk eel** (*Lepophidium cervinum* Goode and Bean)

Jordan and Evermann, 1896–1900, p. 2484.

Description.—The cusk eel is eel-like in form, all its fins are soft and, eel-like, there is no separation between the dorsal, caudal, and anal, but the three form one continuous fin running backward along the back, around the tip of the tail, and forward on the lower surface. It is separated from all the true eels, however, by the presence of ventral fins, which are situated on the throat far in front of the pectorals and are reduced to forked barbel-like structures. The structure of the ventral fins and the uninterrupted dorsal fin separate it from the eelpout, its nearest relative among local fishes, and the presence of a short sharp spine on the top of the snout pointing forward and downward, and easily felt if not seen (for it is nearly concealed in the skin), likewise differentiates it from such other Gulf of Maine species as it resembles in general appearance. The shape of the snout is likewise diagnostic, as are its large scales, for the other genera of its family have naked heads with the scales on the body very small.

Color.—Described as brownish yellow, the upper sides and back marked with roundish white spots, the dorsal and anal fins with narrow black margins.

General range and occurrence in the Gulf of Maine.—This fish has been taken at various localities along the outer part of the continental shelf from off Florida to abreast of Nantucket in depths of 52 to 102 fathoms. It is mentioned here because of the capture of one specimen in 76 fathoms off Nantucket Shoals.[51]

[50] Smitt. Scandinavian Fishes, 1892, p. 613.

[51] Goode and Bean, 1896.

THE SILVER HAKES AND CODS. FAMILIES MERLUCCIIDÆ AND GADIDÆ

The silver hakes and the cods are so closely allied that many European ichthyologists group them in a single family. American practice, however, is to separate them because of certain differences in the structure of the skull and ribs. They are soft-finned fishes, lacking true spines at any stage in development (though in one local species (the silver hake) the basal parts of the dorsal and anal fin rays are so stiff as to feel like spines to the touch) but distinguishable from all other spineless Gulf of Maine fishes by the fact that the large ventrals are situated under or in front of the pectorals, and not behind them, as in herring, salmons, etc. They and their relatives, the grenadiers (p. 467), are also separated from most of the typical spiny rayed fishes by the structure of the skull.[52]

KEY TO GULF OF MAINE HAKES, CODS, ETC.

1. Three separate dorsal and two anal fins; ventrals of ordinary form 2
   Two separate and well-developed dorsal fins 5
   Only one well-developed dorsal fin 11
2. Lateral line black; a black blotch on the shoulder ..... Haddock, p. 432
   Lateral line pale; no shoulder blotch 3
3. Lower jaw projects beyond upper; tail forked; chin barbels very small or wanting ..... Pollock, p. 396
   Upper jaw projects beyond lower; chin barbels large 4
4. Ventrals narrow, prolonged in filamentous feelers as long as the rest of the fin; eye small ..... Tomcod, p. 406
   Ventrals broad, their filamentous tips less than one-third as long as the remainder of the fin; eye large ..... Cod, p. 409
5. The anal fin originates under or behind the point of origin of the second dorsal fin 6
   The anal fin originates considerably in front of the point of origin of the second dorsal fin ..... Hakeling, p. 457
6. Ventrals short; of ordinary form ..... Silver hake, p. 386
   Ventrals very long and feeler-like 7
7. First dorsal hardly higher than second, and none of its rays elongate or filamentous ..... Spotted hake, p. 455
   First dorsal much higher than second, with one or two long filamentous rays 8
8. The ventrals do not reach back to the middle of the anal fin 9
   The ventrals reach nearly or quite to the rear end of the anal fin ..... Long-finned hake, p. 456
9. Anal fin so deeply notched about midway of its length as to suggest two separate fins ..... Blue hake, p. 444
   Anal fin continuous and of about equal height from end to end 10
10. About 140 rows of scales along the lateral line from gill opening to base of caudal fin ..... White hake, p. 446
    Only about 110 rows of scales along the lateral line ..... Squirrel hake, p. 447
11. The dorsal fin is preceded by a fringe of short rays and one long ray; the top of the snout as well as the chin bears barbels 12
    There are no isolated rays in front of the dorsal fin nor barbels on the top of the snout ..... Cusk, p. 462
12. Top of nose with three barbels ..... Four-bearded rockling, p. 458
    Top of nose with oly two barbels ..... Three-bearded rockling, p. 462

[52] The hypercoracoid bone lacks a foramen.

149. **Silver hake** (*Merluccius bilinearis* Mitchill)

WHITING; NEW ENGLAND HAKE

Jordan and Evermann, 1896–1900, p. 2530.

Description.—The presence of two separate and well-developed dorsal fins, both soft-rayed, the second much longer than the first, combined with the jugular location of the ventrals, is sufficient field mark to distinguish the silver hake from all other Gulf of Maine fishes except the true hakes (Urophycis, p. 446). Nor is there any danger of confusing it with any of the latter, for it lacks the chin barbels so characteristic of them, and its ventrals are of the ordinary finlike form, those of the true hakes altered into long feelers. It is a rather slender fish, about 6½ times as long as deep, its body compressed in front of the vent but rounded behind it, with large flat-topped head occupying about one-fourth of the total length, large eye, and wide mouth armed with two or more rows of very sharp recurved teeth, its lower jaw projecting beyond the upper. The first dorsal fin (13 to 14 rays) originates close behind the gill opening. It is roughly an equilateral triangle and is separated by a short space from the second, which is about four times as long (41 rays) but hardly more than half as high and is of very characteristic outline, being deeply emarginate two-thirds of the way back, with its rear section highest and rounded, suggesting an incomplete separation into the three dorsal fins of the cod. The anal fin (40 rays) corresponds in height and outline to the second dorsal, under which it stands. The caudal is square-tipped, the pectorals broad, slightly rounded, and reaching back far enough to overlap the second dorsal. The ventrals, situated slightly in front of the pectorals, are slightly shorter than the latter with about half as many (7) rays. The scales are of moderate size, relatively smaller than those of the true hakes.

Color.—When fresh caught the silver hake is dark gray, of a brownish cast, showing golden reflections above and with its lower sides and belly silvery, as its name implies. The inside of its mouth is dusky and the lining of its belly is blackish.

Size.—Maximum length about 2 feet and weight 8 pounds, but adults average only about 14 inches long.

General range.—Known from the Bahamas to the Grand Banks, from the coast line out to the continental slope, and from tide mark down to about 300 fathoms, most abundantly between Cape Sable and Cape Cod. According to Doctor Huntsman all ostensible reports of its presence in the Gulf of St. Lawrence belong in reality to the other hakes (Urophycis, p. 446), and it is these that are meant when "hake" are spoken of in the earlier publications of the Bureau of Fisheries—for instance, in Baird's (1889) report on the fisheries of eastern North America. The silver hake is represented in Europe by a close relative—the European hake (*Merluccius merluccius*)—an excellent account of the natural history and migrations of which is given by Le Danois.[53]

Occurrence in the Gulf of Maine.—In season, and allowing for wide fluctuations from year to year, the silver hake is a familiar fish all around the coasts of the Gulf of Maine from western Nova Scotia to Cape Cod. It is common, also, in the south

[53] Notes et Mémoirs No. 2, Office Scientifique et Technique des Pêches Maritimes, Juin 1920, 32 pp. Angers.

channel, on Georges Bank, and on the outer part of the shelf off southern New England, and though we have not been able to obtain definite data as to its status on Browns Bank, it probably visits the latter also. It occurs in such multitudes in Massachusetts Bay and on the sandy shores of Cape Cod that millions are

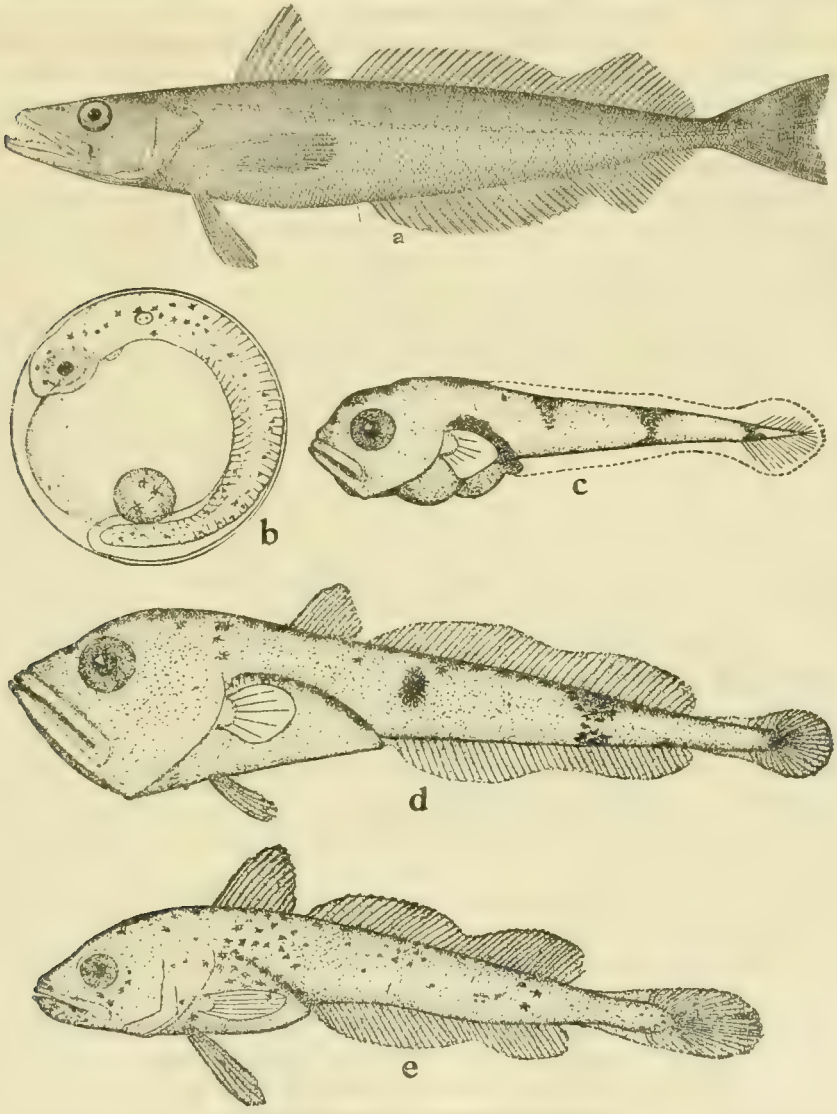

FIG. 194.—Silver hake (*Merluccius bilinearis*)

a, Adult. *b*, Egg. *c*, Larva, 6.5 millimeters. *d*, Larva, 11 millimeters. *e*, Fry, 23 millimeters

taken in the local weirs every summer, and some idea of the present-day abundance of this fish along our shores may be gained from the fact that in 1919 the shore fisheries reported 687,970 pounds in Maine and more than 13,000,000 pounds (at least 7,000,000 fish) in Massachusetts, which was but a fraction of the actual total

catch, for although a demand for it has recently arisen the market is still so uncertain that multitudes are often thrown away. Silver hake are usually most plentiful between Cape Cod and Casco Bay, with Cape Cod Bay perhaps the chief center of abundance. Great numbers are caught all along the eastern coast of Maine and at the mouth of the Bay of Fundy in autumn.

The schedules of catches from the otter-trawl investigations of 1913 afford the only available data on the numerical strength of silver hake on Georges Bank with relation to other fish, nor can these be held conclusive because this gear is not as well suited to the capture of such an active mid-water species as of the more lethargic ground fish, hence probably understate it. So far as they go, however, the records suggest not only that silver hake are much less plentiful than haddock on the bank, the average catches per trip (April to September) being about 14,000 individuals of the latter and only about 1,800 of the former, but that it is less regular, for several trips missed them altogether.

The silver hake, like the mackerel, is strictly a summer fish in the Gulf of Maine, sometimes appearing in the Massachusetts Bay-Cape Ann region as early as the last week in March and regularly striking there by May. In 1913 (a fairly representative season) Welsh saw odd fish in Ipswich Bay in March and April, considerable numbers in May, and an abundance was seined there in June, which may be taken as typical for the whole coast line of the Gulf south of Portland. This applies equally to Georges Bank, where in 1913 the first silver hake were taken by the otter trawlers from April 27 to 29 and on almost every trip thereafter. We have not been able to learn how early silver hake appear on the coast of Maine east of Portland, or off western Nova Scotia, where it is only within the past few years that any attention has been paid them; but this certainly happens by the end of May, for Huntsman says they are to be found in summer in the Bay of Fundy. They vanish from the coastwise waters and from the offshore banks alike sometime late in the autumn. General report and my own experience is that November sees the last of them in Massachusetts Bay, and while they linger on Georges Bank until well into December (latest catch December 3 to 12 in 1913) none were reported there during the last half of that month or in January, February, or March during 1913.

There is no reason to doubt that this appearance in spring and the corresponding disappearance from the northern parts of its range in autumn is the visible evidence of an actual and widespread seasonal migration. Essentially this is a vernal movement inshore into shoal water and an offshore journey into deeper water for wintering, but for such fish as visit the inner parts of the Gulf of Maine this necessarily entails a considerable north and south journey as well, for it is probable that silver hake do not winter in the deep basin of the Gulf but withdraw from it altogether at the approach of cold weather. The European silver hake performs a corresponding immigration into the North Sea in early summer and emigrates out again in autumn. However, the parallel is not complete, for while the North Sea serves chiefly as a feeding ground for the spent fish, the Gulf of Maine is an important spawning area; and while hosts of silver hake repair thither and to its offshore banks, other multitudes summer on the continental

shelf abreast of southern New England in depths of from 50 down to 300 fathoms, a fact proven by the capture of great numbers of them, and of all sizes from fry of one-half to 3 inches to adults of 12 to 18 inches, green, ripe, and spent, by the vessels of the United States Bureau of Fisheries.[54] Probably it is this body of silver hake and not the Gulf of Maine fish that are sometimes common at Woods Hole in summer and that congregate along the shores of southern New England for a brief period in autumn, to vanish, however, in winter.

The wintering ground of the Gulf of Maine stock of silver hake is not definitely known. Analogy with the European species suggests that the bottom along the upper part of the continental slope so serves, and this is corroborated by the fact that on February 20 to 21, 1920, the *Albatross* trawled several specimens in 90 and 190 fathoms along the continental edge off Chincoteague, Va., and off Delaware Bay, together with spiny dogfish (*Squalus acanthias*, p. 47). Once the silver hake have journeyed out past Cape Cod and Georges Bank there is no reason to suppose they turn southward, but rather that they simply descend the slope until they find suitable physical surroundings, whether of temperature, salinity, or of absolute depth. Definite information on this point is much to be desired, and this may be hoped for from scale studies, which, by revealing the existence of local races on different sections of the coast, differing in their rate of growth,[55] have afforded positive evidence that the migrations of the European hake are primarily in and off shore, not north and south.

While sojourning in the Gulf of Maine silver hake are caught regularly from the surface (for they come right up to tide mark) down to 40 or 50 fathoms, and they have been trawled down to 100 fathoms and more in its basin even in summer, and to 300 fathoms on the continental slope, as just noted. In short, this fish is independent of depth within wide limits, and of the bottom, inhabiting the mid-levels of the sea, its movements governed by spawning and by the pursuit of food. It is a very interesting fact that all the great armies of silver hake that enter the traps and strand on the beaches of the Gulf of Maine are composed of good-sized individuals of 8 inches and longer, and that immature fish from yearlings on, such as make up the greater part of the catch of herring, are so rare that most of the local fishermen of whom we have inquired know nothing of them north of Cape Cod except that fry about 3 inches long, hence probably of the same summer's hatch, have been reported to us as found on the flats at Plymouth. Huntsman, however, reports all stages from yearlings on in the Bay of Fundy. Such evidence at face value might indicate that adults actually dominate the bodies of silver hake in most parts of the Gulf of Maine, most of the immature fish lingering nearer their wintering ground; but an equally reasonable and far more probable explanation is that immature fish are in reality as plentiful in the inner parts of the Gulf as the abundance of adults suggests, but that they are not caught in the traps because they do not come so close inshore.

Food and habits.—Silver hake are strong swift swimmers, well armed and extremely voracious. They prey on herring and on any other of the smaller schooling fish, such as young mackerel, menhaden, alewives, silversides, etc.; also on

[54] These records are listed by Goode and Bean, 1896, p. 387.

[55] Belloc. Notes et Mémoirs No. 21, Office Scientifique et Technique des Pêches Maritimes, Janvier 1923, 32 pp. Paris.

squid and occasionally on crabs and other crustaceans. Probably a complete diet list would include the young of practically all the common Gulf of Maine fishes, for Vinal Edwards recorded the following considerable list from the silver hake taken at Woods Hole: Alewife, butterfish, cunner, herring, mackerel, menhaden, launce, scup, silversides, smelt, and its own species, and probably the silver hake that frequent Georges Bank feed chiefly on young haddock.

Though they do not school in definite bodies multitudes of these fish often swim together, and such bands often drive herring ashore and themselves strand in pursuit. Events of this sort are oftenest reported in early autumn when the spent fish are feeding ravenously after the effort of spawning, but they may also happen at any time during the summer. For example, Prof. A. E. Gross saw the beach at Sandy Neck, Barnstable, Mass., literally covered with them on several occasions in June and July, 1920.[56] Doctor Huntsman informs us that spent fish frequently strand on the beaches on both sides of the Bay of Fundy in September. We once saw an army of silver hake harrying a school of sperling in but a few inches of water on a shelving beach at Cohasset, Mass.—in fact, half filled a canoe with pursuers and pursued with my bare hands—and from time to time visitors to the seashore complain that the air is fouled with the stench of the rotting carcasses. In fact we doubt if we have ever walked a couple of miles along the beach about Massachusetts Bay at any time between June and October without seeing at least one silver hake high and dry.

It is said that European silver hake rest on the bottom by day and hunt by night, and it is usually at night that the American fish run up into the shallows and enter the traps, but strandings also take place by day. When they are on bottom they keep to sandy or pebbly ground, seldom being caught on mud or about rocks, in which, as in most of their ways, they correspond to the European species. It has long been known that the latter fluctuates widely in abundance from year to year throughout its range. Unfortunately fishery statistics throw no light on this point for the American fish, which was looked on as nothing but a nuisance until half a dozen years ago. Silver hake were reported relatively scarce in the Gulf of Maine during the few and brief periods when bluefish have abounded there (p. 239), nor is this unlikely, as the latter prey upon the former as silver hake do on herring.

Breeding habits.—The silver hake is the most important summer spawner among Gulf of Maine fishes, just as the haddock is for spring and the pollock for autumn, and the Gulf is probably its most prolific nursery. It likewise spawns over the outer part of the Nova Scotian Banks as far east as Sable Island, Dannevig[57] having recorded large egg catches off Halifax. This is probably its eastern breeding limit, however, for the Canadian Fisheries Expedition found no silver hake eggs or fry on Banquereau or Misaine Banks, in the Laurentian Channel, or on the Newfoundland Banks. On the other hand our most westerly egg record was off Nantucket Shoals (fig. 195), nor is it likely that silver hake spawn inshore far west of Cape Cod, unless they do so much earlier in the season there than in the Gulf

[56] The Auk, Vol. XL, January, 1923, No. 1, p. 19.
[57] Canadian Fisheries Expedition, 1914–15 (1919), p. 27.

of Maine.[58] Kuntz and Radcliffe (1918) were unable to hatch its eggs at the Woods Hole hatchery, though they were taken from ripe females caught in the local weirs,

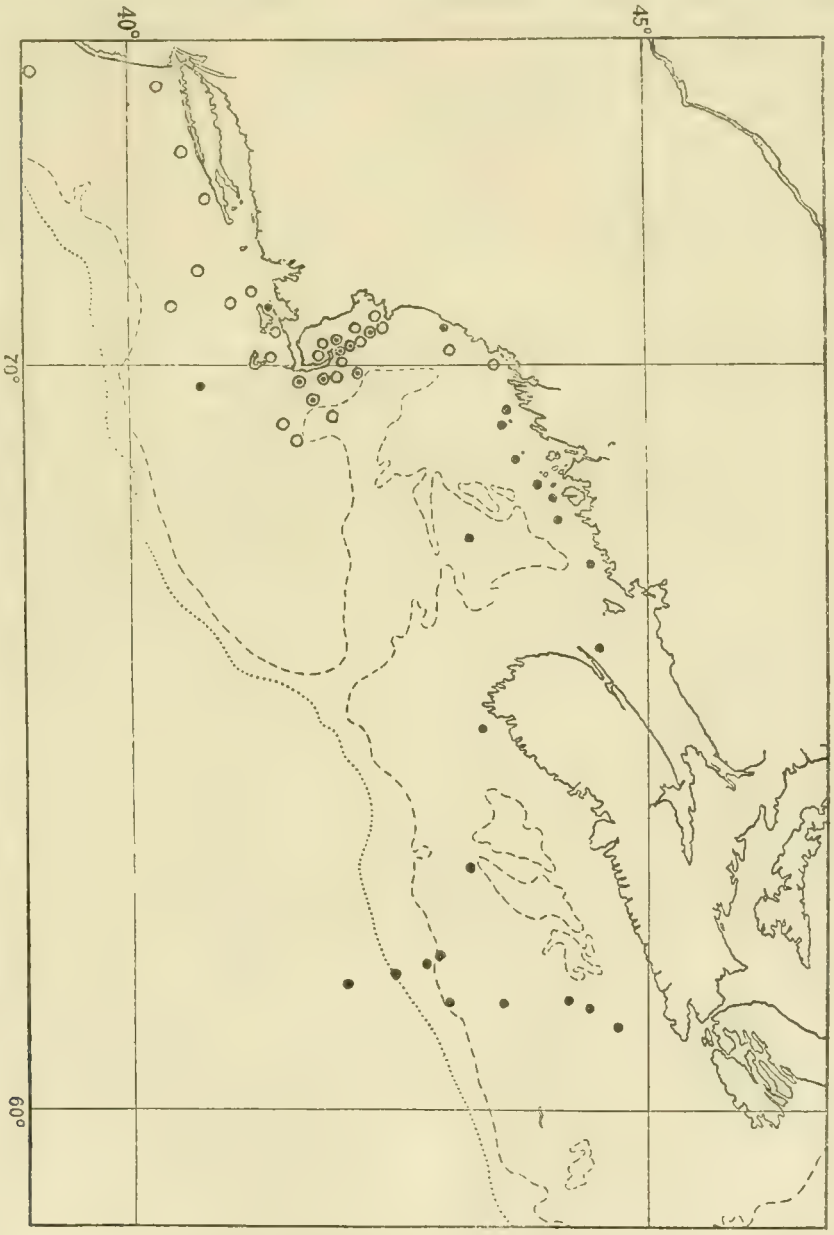

FIG. 105.—Localities where eggs (●) and larvæ (○) of silver hake, or both (◎), have been taken

and though eggs in fair number were taken in the tow nets in July and August, but it may spawn successfully to the southern limit of its range in deep water offshore.

[58] The European silver hake spawns from January until May in the Mediterranean, but not until July and August in British waters.

The silver hake spawns here and there along the entire coastal zone from Cape Cod to Grand Manan, as proven by the locations of the egg catches (fig. 195), but apparently it does not breed successfully on the northern side of the Bay of Fundy where neither its eggs nor its fry have ever been found. The observations related below (p. 393), suggest that it is the low surface temperature of this locality that prevents its successful reproduction there, but the capture of a few eggs in Petit Passage in our tow nets on June 10, 1915, suggests that it, like the cunner, may spawn on the southern side of the bay. There is no positive evidence at hand that it breeds along the west coast of Nova Scotia, but this is to be expected; and its presence in abundance on Georges Bank throughout the summer is also presumptive evidence of local spawning, though we have taken no silver hake eggs or larvæ there.

The silver hake that spawn within the Gulf of Maine do so chiefly in water shoaler than 50 fathoms, corresponding in this to our other numerically important gadoids, whereas the Eureopean silver hake usually spawns in 50 to 100 fathoms. We made one rich haul of its eggs in the center of the eastern basin, which need be no surprise, the silver hake being more pelagic in its habits than the cod tribe and wandering far and wide in pursuit of prey. The discovery of ripe as well as of green and spent fish in depths as great as 300 fathoms off southern New England (p. 389), and of its eggs outside the continental slope off Nova Scotia by the Canadian Fisheries Expedition,[59] prove that it spawns over deep water as well as in shoal water.

The silver hake of British waters congregate on certain definite banks to spawn. Whether our American fish does the like is yet to be learned, but judging from its wandering habits it is not likely to be as select in its choice as is the haddock, for example. The sloping sandy bottom around the northern extremity and off the eastern slope of Cape Cod is evidently an important center of reproduction, for not only did we find an abundance of eggs off Race Point on July 7, 1915, but our tow nets yielded swarms of young larvæ and many eggs at two stations off the outer side of the cape on July 22 of the following year, with the fish still spawning there a month later, as proved by the presence of eggs. Other localities where we have taken silver hake eggs in large numbers are off Duck Island near Mount Desert on July 19 and August 18, 1915; near Monhegan Island, August 4, 1915; off Wooden Ball Island near the mouth of Penobscot Bay on August 6, 1915; and off Rye, New Hampshire, on July 23 of that same year; but we have never found them in any number in Massachusetts Bay though odd eggs have been taken there on several occasions (fig. 195). Unfortunately no quantitative hauls were made at any of the more productive egg stations, hence the number of silver hake eggs actually present in the water can not be approximated, and our general experience has been that vertical hauls with small nets are of little use for fish eggs when there are less than 50 or so of the latter per square meter of sea surface. But the vertical net yielded about 190 per square meter at the eastern basin station just mentioned, where eggs also occurred in fair number in the horizontal hauls.

[59] Dannevig. Canadian Fisheries Expedition, 1914-15 (1919), p. 28

Although silver hake appear as early as April or May in the Gulf of Maine we have no evidence that they commence to spawn before June north of Cape Cod, our earliest egg record being for the 11th of that month. Spawning, as evidenced by captures of the eggs in tow nettings, is at its height in July and August and continues through September, though less freely, with October 22 as our latest date. Similarly, the Canadian Fisheries Expedition found no silver hake eggs in Nova Scotian waters east of Cape Sable in May, but many in July, while Kuntz and Radcliffe describe the silver hake as spawning in July and August about Woods Hole

According to their observations [60] only part of the eggs mature at a time, hence the silver hake, like the mackerel, belongs to the rather numerous category of fishes, individuals of which spawn over a considerable period.

The temperatures and salinities in which silver hake spawn in the Gulf of Maine vary widely, consequent on the considerable area serving as spawning grounds and on the prolonged spawning season. Owing to the sharp temperature gradient prevailing in most parts of the Gulf at the height of the breeding season it is impossible to establish the exact temperature at which silver hake are spawning at any particular station without knowing at what level in the water the ripe fish are—which may be anywhere between the surface and the bottom with this species. It may be definitely stated, however, that they never spawn in as cold water as cod and haddock usually do in the western Atlantic. In 1915, for example (a representative season), it was not until the entire column of water was slightly warmer than 41° at the locality in question that we found the first silver hake eggs. If the parent fish were in the upper water layers, which the general habit of this species suggests, all the rich spawnings we encountered in the Gulf during that and the following year took place in temperatures considerably higher.

Station	Date	Depth, fathoms	Surface temperature	Bottom temperature
10300	July 7, 1915	27	62	44.1
10302	July 19, 1915	24	52.9	45
10303	Aug. 4, 1915	41	52.9	42.7
10305	Aug. 18, 1915	27	51.5	47.8
10344	July 22, 1916	43	60.5	39.5
10345	do	82	50	39.2
10355	July 25, 1916	16	53.5	51.7

Similarly the silver hake eggs taken off Halifax by the Canadian Fisheries Expedition in July, 1915, and off Shelburne, Nova Scotia, by the *Grampus* on September 6 of that year, may have been spawned in water warmer than 50°, and probably were in temperatures higher than 41°, there being no necessity for assuming that the parent fish were lying in the colder bottom stratum. As the spawning season draws to its close in September and October the minimum temperatures for most of our egg stations have been higher than 46°, with one (our latest record for the season) as warm as 57°. These data point to 41° to 45° as about the lower temperature limit to the spawning of the silver hake, with 45° to 55° as the range of temperature within which most of the eggs are produced.

[60] Kuntz and Radcliffe (1918, p. 109) describe the spawning and early development.

In the case of any fish producing buoyant eggs the tendency of the latter to rise insures (unless it be counteracted by active vertical circulation of the water) that development shall take place in the temperature of the surface layer, not of the deeper lying water in which they are spawned. In most parts of the Gulf of Maine, too, where the surface is much warmer than the underlying water strata in summer, it follows that buoyant eggs produced as much as a few fathoms down incubate, and the larvæ at hatching find themselves in temperatures considerably higher than those in which spawning takes place. The silver hake is no exception to this rule. While we have towed its eggs in June when the surface was still only about 42°, most of the egg records, with all the rich catches, were made in temperatures ranging from 51° to 63°; and at the few localities where we have taken newly hatched larvæ (less than 4 mm. long), the upper stratum of 5 fathoms or so, where hatching may be assumed to have taken place, has invariably been warmer than 50° and usually warmer than 55°, with the temperature of the immediate surface 60° or higher in most cases. Such evidence suggests that incubation does not proceed normally in water cooler than about 50°, and that development is most successful in temperatures as high as 55° to 60°. Thus, though the silver hake may spawn in low temperatures, a comparatively warm surface layer is necessary for the later stages in its propagation. This is interesting in its application to the Gulf of Maine for it offers a reasonable explanation of the failure of this fish to breed successfully along the New Brunswick shore of the Bay of Fundy, where active vertical circulation maintains surface temperatures as low as 50° to 55° throughout the summer. On the other hand, however, the failure of the eggs to develop in the hatchery at Woods Hole points to 65° to 70° as the upper limit to successful incubation.

Spawning takes place in comparatively low salinities in the Gulf of Maine, with a vertical range at the "egg" stations of from about 31.5 to about 32.5 per mille, while 33 per mille may be set provisionally as the maximum salinity in which any silver hake eggs develop in the Gulf, water far less saline than that in which the European silver hake spawns and in which its eggs develop.

Our frequent captures of silver hake larvæ at many localities (fig. 195) prove that it not only spawns freely in the Gulf of Maine but that the eggs develop, and that the southwest part of the Gulf at any rate (p. 395) is a favorable nursery for them. Furthermore silver hake have been the subject of our richest haul of young fish, a 15-minute haul at 20 fathoms with a net one meter in diameter off Cape Cod on July 22, 1916 (sta. 10344) having yielded approximately 25,000 larvæ of 3 to 7 mm.

We know of no estimate of the number of eggs a single female may produce. The eggs are buoyant, transparent, about 0.88 to 0.95 mm. in diameter, with a single yellowish or brownish oil globule of 0.19 to 0.25 mm. Incubation is rapid; Kuntz and Radcliffe assumed 48 hours at Woods Hole, but its duration has not been determined for the cooler water in which the eggs are produced naturally in the Gulf of Maine. The larvæ are about 2.8 mm. long at hatching, slender, with comparatively small yolk sac, and recognizable by the facts that the vent is located close behind the latter on one side near the base of the larval fin fold as in the cod family, not at its margin as in most larval fishes, and that the trunk behind the vent is

marked with two black and yellow transverse bars. In larvæ of 6 to 7 mm. the yolk has been absorbed and the caudal fin rays have appeared; the dorsal and anal fins assume their definite outlines by the time the little fish is 10 to 11 mm. long; and fry of 20 to 25 mm. begin to resemble their parents.[61] The position of the vent together with the transverse pigment bars are diagnostic for the youngest larvæ, while the large head, slender trunk, and, in older larvæ, the outlines of the dorsal fins are diagnostic of the later larval stages.

The locations at which silver hake eggs and larvæ have been taken (fig. 195) exhibit one very striking phenomenon—total failure to find larvæ at the more northern and eastern stations or eggs at the more southern and western stations. Dannevig[61a] has already called attention to the absence of larvæ contrasted with the abundance of eggs in Nova Scotian waters, suggesting that the disparity may mirror the percentage of eggs that survive and hatch there. Such calculations, it is true, must rest on very slender bases until more is known of the biology of this fish, nor does the presence of larvæ contrasted with apparent absence of eggs west of Cape Cod in summer prove that the former pass the cape only as immigrants from east and north, for silver hake may spawn there so early in the season that their eggs have escaped the summer tow nettings. We have towed so often along the coast of Maine in August, September, and October, however—that is, just the season when the larvæ spawned from June to August might have been expected—that failure to find larvæ east of Cape Elizabeth in the Gulf of Maine, contrasted with their frequent capture and local abundance (p. 394) in the Massachusetts Bay region, seems sufficient evidence that they are actually limited in their occurrence to the southwestern part of the Gulf, in which young silver hake parallel the young cod, haddock, and flatfish. This phenomenon, with other similar facts of distribution suggests a peripheral drift around the shores of the Gulf from northeast to southwest, in which first the eggs and then the resultant larvæ take part. So well, indeed, has this type of circulation been established for the Gulf by hydrographic evidence that some such involuntary migration is inevitable, not only for buoyant fish eggs and larvæ produced near the coast line, but likewise for the whole category of pelagic invertebrates and plants.

Presumably the young silver hake takes to the bottom during its first autumn when about 1 to 1½ inches long, as does its European relative. Indeed, such small fry have been trawled in deep water off southern New England (p. 389).

The rate of growth of the American silver hake is yet to be studied, nor can it be deduced from that of the European species, for the latter grows to a considerably greater length, averaging as much as 30 inches at 8 years in the extreme north of its range (Iceland) and considerably larger in the south (Gulf of Gascony and off Morocco [62]). It is fair to assume, however, that the growth of the American fish varies similarly with latitude (that is, is most rapid in high temperatures) and

[61] Kuntz and Radcliffe (1918, p. 109) describe the early stages.

[61a] Canadian Fisheries Expedition, 1914-15 (1919).

[62] Belloc Notes et Mémoires No. 21, Office Scientifique et Technique des Pêches Maritimes, Janvier 1923, 32 pp. Paris.

that the American female, like the European, grows faster than the male. The European Merluccius matures at 2 years, which is probably true of the American, also.

Commercial importance.—Although this is one of our sweetest fish if eaten perfectly fresh, it so soon softens that there was no regular sale for it until very recently, and we can remember it used locally as manure. The demand has grown so rapidly, however, that whereas only 37,000 pounds were saved in Massachusetts and Maine in 1895, more than 2,300,000 pounds were marketed there in 1902, almost 4,500,000 in 1905, and more than 14,000,000 in 1919. Practically all the silver hake sold are from the weirs and traps, the price they command still being so low that the bank fishermen throw them overboard as trash.

150. **American pollock** (*Pollachius virens* Linnæus)

POLLOCK; BOSTON BLUEFISH; COALFISH (EUROPEAN)

Jordan and Evermann, 1896–1900, p. 2534.

Description.—The American pollock [63] is a shapely fish with deep, plump body (about four and one-fourth times as long as deep) tapering to a pointed nose and slender caudal peduncle. Its mouth is of moderate size. The projecting lower jaw (giving it an undershot facial aspect), its forked sharp-cornered tail, small ventrals, and small chin barbel (as a rule the latter is lacking altogether in large fish), with its beautiful green color, are ready field marks when it is taken with cod and haddock. Its first dorsal fin (13 rays), originating slightly behind the pectoral, is triangular, slightly the highest of the three dorsals. The second dorsal, also triangular, is longest (22 rays) and separated by a considerable space from the third (20 rays), which is more rhomboid in outline. The second anal fin (20 rays) corresponds in shape and size to the third dorsal, under which it stands, but the first anal is considerably longer than the second dorsal though of similar outline. The ventrals are slightly in front of the pectorals and only about half as long. The pectorals are set high on the sides, longer than the first and shorter than the second dorsal, with rounded lower corners and bluntly pointed tips. The caudal fin is noticeably forked, with angular corners unless spread to its widest, when its margin becomes early straight.

Color.—Pollock are always of a greenish hue, usually deep rich olive or brownish green above, paling to yellowish or smoky gray on the sides below the lateral line and to silvery gray on the belly. The lateral line is white or very pale gray, contrasting strongly with the dark sides. The dorsal, caudal, pectoral, and anal fins are olive, the latter pale at the base. The ventrals are white with a reddish tinge. Young fish are darker than large ones and often more tinged with yellow on their sides.

Size.—Gulf of Maine pollock reach a maximum length of 3½ feet and a weight of about 35 pounds, but fish as heavy as this are exceptional, few growing larger than 40 inches or 25 pounds, with about 2 to 3 feet and 4 to 12 pounds as the average

[63] This is the "coalfish," green cod," or "saithe" of European fisherman. The European "pollack" is a different species (*Gadus pollachius*).

for adults. A ripe female of 40 inches will weigh about 24 pounds, while one of 38 inches will weigh 17 pounds. The proportion of length to weight was as follows among fat fish taken off Boon Island on April 22 to 25, 1913, and measured by Welsh:

Length, in inches	Weight, in pounds	Length, in inches	Weight, in pounds
35	13¾	29½	9
33	12	29½	9
32	11½	29½	8½
32	10	29½	9
32	12	29	8
32	11	29	9
31½	10	28½	8
31	10	27½	8½
30	9½	27	7½
30	9¼	26	4
30	8½	24½	5½
30	9	24½	5½
30	8½	24½	4

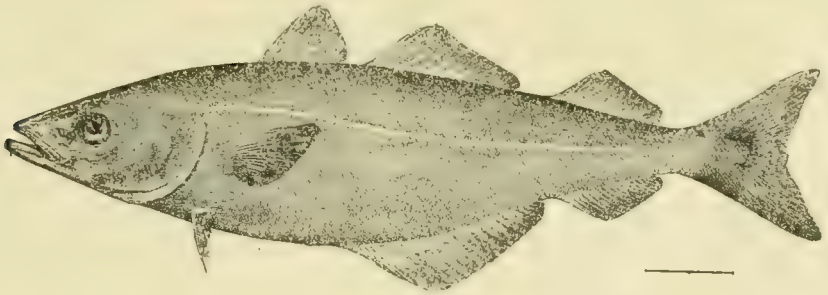

FIG. 196.—Adult

FIG. 197.—Egg (European). After McIntosh

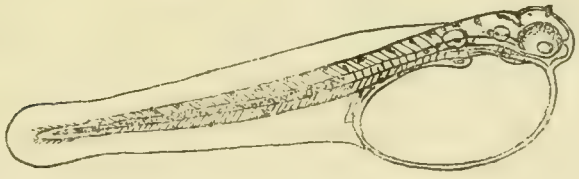

FIG. 198.—Larva (European), 5 days old, 4.3 millimeters. After McIntosh

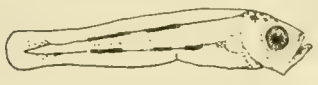

FIG. 199.—Larva (European), 6.75 millimeters. After Schmidt

FIG. 200.—Larva (European), 12.5 millimeters. After Schmidt

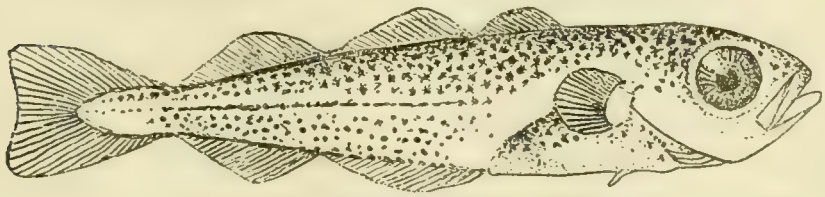

FIG. 201.—Fry (European), 23 millimeters. After Schmidt

AMERICAN POLLOCK (*Pollachius virens*)

General range.—Both sides of the North Atlantic. On the American coast pollock have been taken as far south as Chesapeake Bay,[64] though they are very rare beyond New York. They occur regularly in small numbers in Narragansett Bay and are plentiful from the Woods Hole region, Nantucket Shoals, and Cape Cod to Cape Breton. They also enter the southeastern part of the Gulf of St. Lawrence but are not plentiful enough farther in to appear in the fishing returns, and they are unknown along its north shore though odd fish have been reported as far north as Hudson and Davis Straits.

Occurrence in the Gulf of Maine.—The Gulf of Maine is the chief center of abundance for this fish on the western side of the Atlantic, and it is one of the half dozen species that support the great commercial fisheries of the Gulf. Pollock are caught in abundance all around its shores from Cape Sable to Cape Cod.

Pollock, unlike cod and haddock, are most abundant in the coastal belt from close to land out to about the 75-fathom contour, but though pollock are seldom reported over the deep basin they are caught in fair numbers on the offshore banks. The reader will gain some idea of the abundance of this fish and how universal it is along the coasts of the Gulf from the following statistics of the shore catch for the year 1919. The west coast of Nova Scotia from Cape Sable to the mouth of the Bay of Fundy reported about 1,000,000 pounds; the Scotian side of the bay, more than 4,500,000 pounds; the New Brunswick shore nearly 8,000,000; the coast of Maine east of Casco Bay nearly 3,000,000 (these three items just mentioned include the landings from German Bank, from the vicinity of Lurcher Shoal, and from Grand Manan Bank); and Casco Bay to the Merrimac River more than 1,000,000 pounds. Twelve million odd pounds were also taken by the gill-netters between Portland and Provincetown, chiefly in the neighborhood of Boon Island and the Isles of Shoals, on Jeffreys Ledge, and in Massachusetts Bay, while 6,000,000 pounds more, caught inshore by larger vessels, can not be classified by locality. This totals nearly 36,000,000 pounds.

Pollock can not be described as abundant anywhere west of Cape Cod and Nantucket, but small amounts (small by comparison with the Gulf of Maine landings) are yearly caught in season (p. 400) along the southern shores of New England and in New York waters, and a few even as far as New Jersey. For instance, Rhode Island reported 291,430 pounds in 1905 and about 100,000 pounds in 1919; Connecticut, 322,116 and 28,400 pounds, respectively, in these two years; New York, 81,710 pounds in 1915 and 279,451 pounds in 1917; and New Jersey 12,824 pounds in 1915 and 40,611 pounds in 1917.

Practically all the fish that compose the shore catch are caught within 20 and most of them within 10 miles of land. Many, in fact, are taken right along the shore, as appears from the fact that the weirs and traps of Maine and Massachusetts yielded 1,000,000 pounds in 1919, but the most successful fishing is with gill nets, as just noted.

Pollock has always been one of the principal fish caught with hook and line on the banks and ledges in the inner part of the gulf, near Lurcher Shoal for in-

[64] W. C. Schroeder of the Bureau of Fisheries informs us that a pollock 12 inches long (identified by Dr. W. C. Kendall) was taken at Buckroe Beach, Va., on March 26, 1894. Previous to this its most southerly record was off New Jersey.

stance, on Grand Manan Bank, on Jeffreys Ledge, and on Stellwagen Bank at the entrance to Massachusetts Bay.

They are also caught regularly by the line trawlers and in less amount by the otter trawlers on all the offshore fishing grounds, but as a rule the catches brought in thence are insignificant compared with those of the inshore fishery, as the following figures for 1919, a fairly representative year, will illustrate:

Location	Pounds
Browns Bank [65]	157, 080
Georges Bank and "off Chatham"	1, 059, 512
Cashes Ledge and vicinity	15, 988
South Channel	672, 335
Nantucket Shoals	38, 467
Jeffreys Ledge	92, 890
Platts Bank	30, 555

Sometimes, however, larger quantities are brought in from one or the other of the outer fishing grounds than in the year just analyzed—3,260,000 pounds from the South Channel in 1921, for example. In the grand total the yield of pollock may be expected to average at least 35,000,000 to 40,000,000 pounds for the whole Gulf of Maine—say 5,000,000 to 6,000,000 fish, taking one year with another.

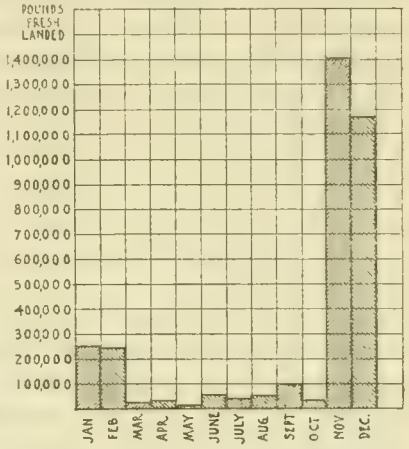

FIG. 202.—Monthly landings of fresh pollock at Gloucester for the year 1921

Small pollock 4 to 10 inches long and weighing less than half a pound (that is, 1 or 2 years old) swarm inshore after early April, when we have seen thousands taken from the traps at Gloucester and Magnolia. In the southern part of Massachusetts Bay these "harbor pollock," as they are called locally, move out in June, probably to avoid the rising temperature, to work back in autumn, but they remain very abundant all summer and autumn in the harbors and bays and among the islands all along the coast from Gloucester north and east to Nova Scotia. In winter, however, most of them seek slightly deeper water, probably to avoid the cold.

The larger fish, as is usually the case, keep farther offshore than the small ones, and on the whole live deeper except when pursuing some particular feed (p. 401). They are caught in more definite localities—not everywhere and anywhere along the coast as the little immature fish are. In the southern part of the Gulf, as exemplified by Massachusetts Bay and the belt from Cape Ann to the Isles of Shoals, large pollock are taken in greatest number in late autumn and early winter when the gill-net fishery taps the spawning fish (fig. 202), and they often appear in abundance near land during April and May. However, they so generally move out and into deeper water as the surface warms up with the advance of the

[65] These are only the landings by United States vessels. Probably Canadian vessels landed as much more from Browns Bank in various Nova Scotian ports.

season that few are taken inshore in the Massachusetts Bay region during July and August, though they do not travel far or sink deep, for good fares of large fish 2 to 3 feet long are brought in by line fishermen from Jeffreys Ledge throughout the summer, most of them caught some distance above bottom.

North of the Isles of Shoals pollock are more commonly seen on the surface during the hot months. For example, small boats from Cape Porpoise and neighboring ports were doing well drailing during July and early August, 1922, and great numbers of large pollock are caught all summer in the cool surface waters at the mouth of the Bay of Fundy in ripplings and tide rips, while middle-sized fish swarm for some distance up the bay in the strong tideways on both sides—for instance, about Eastport and in Digby Gut. However, pollock decrease in numbers passing up the bay and fail altogether at its extreme head.

When the breeding season draws on in autumn large pollock again congregate in abundance along the coast line from Cape Porpoise to Cape Ann and off Massachusets Bay, and it is in late autumn and winter that the gill-netters make their largest catches there. But few are caught there after spawning until the following April, showing that the spent fish do not winter on particular grounds but scatter and wander to and fro in search of food.

On Georges Bank and the other offshore fishing grounds pollock are caught all through the year, with no greater seasonal fluctuation in the landings than might result from the various vicissitudes of chance, weather, and the market.

Although its spawning and feeding journeys may lead the pollock right across the Gulf of Maine it is not a "migratory" fish there in the sense in which that term is popularly understood, but one of the most characteristic residents. It becomes migratory west of Cape Cod, however, because the bodies of fish that appear off southern New England in autumn and spring vanish thence when the water warms to about 60° and 65°, all probably withdrawing to the eastward to Nantucket Shoals and past Cape Cod to pass the summer, and most of them breeding in the Gulf of Maine.

Habits and food.—The pollock is an active wandering fish, living at any level between bottom and surface, often schooling like the mackerel, and sometimes gathering in bodies so large that it is on record that a purse seiner once took 60,000 out of one school at a single set. It is predaceous, feeding chiefly on small fish and on pelagic crustaceans—among the latter most often on the large pelagic shrimplike euphausiids, and it is the local presence or absence of prey that governs the movements of the larger fish and their schooling.

It is a commonplace that pollock destroy great quantities of small herring, launce, young cod, young haddock, young hake, silver hake, and other small fish in the Gulf of Maine just as they do on the other side of the Atlantic, and, although we can not offer exact particulars of this, pollock chasing schools of herring are a familiar sight,[66] while fish of 1 to 1½ pounds commonly run up estuaries in pursuit of smelt in autumn. Haddock or other larvæ liberated in harbors are always in danger of being snapped up by the young pollock so plentiful in such situations.

[66] Sars (Report of the Commissioner of Fish and Fisheries, 1877 (1879), p. 619-620) has given a graphic account of pollock rounding up schools of launce and young cod in Norwegian waters.

When a pollock only 9 inches long is capable of eating 77 herring up to 2½ inches in length at one meal,[67] "ravenous" is but mildly descriptive. However, pollock so seldom strand in pursuit of prey that we have never seen one on the beach though schools often come close in, witness the catches in the traps.

According to European accounts the pollock of the eastern Atlantic feed chiefly on fish, but in the Gulf of Maine they depend more on pelagic shrimps. At Eastport, for example, where these (Meganyctiphanes and Thysanoessa) are very abundant all summer, Kendall (1898, p. 180) reports pollock of all sizes not only fattening on them but so evidently preferring them to young herring that he did not find a single "sardine" in a pollock stomach, though these were plentiful enough at the time, and he remarks "if at any time the crustaceans disappeared from a place the large pollock disappeared also." Similarly, Welsh found large pollock in schools feeding on the surface on "shrimp" (*Thysanoessa raschii*) off the Isles of Shoals and off Boon Island in April, 1913, remarking in his field notes for the 25th that "in the last few days pollock have begun to appear in small schools of 400 to 500 fish with the appearance of large schools of feed (shrimp, 'all eyes'), the feed (shrimp) breaking water trying to get away from the pollock which are after them." He described the fish themselves as "rising and sinking at intervals; when at the surface swimming like porpoises, leaping up and over with open mouths, the feed being in dense streaks 6 inches to 1 foot down." These feeding fish were "very sluggish and tame on this feed and easily taken in the purse seines," while all were "stuffed to capacity" with shrimps, only an odd one containing a herring.

Even large pollock sometimes take morsels as small as copepods. Willey (1921, p. 192), for example, speaks of a fish caught near Campobello Island which contained proportionately as many large copepods (Euchæta) as euphausiid shrimps, and likewise the smaller copepods, *Calanus finmarchicus* and *C. hyperboreus*, while he found Sagittæ and caprellids in the stomachs of other pollock. In north European waters, too, the medium-sized fish are known to eat considerable amounts of small copepods, fish eggs, etc., and it is probable that the small fish diet chiefly on these. Pollock also feed to a small extent on bottom-dwelling crustaceans on both sides of the Atlantic, crabs, prawns, and bottom-dwelling shrimp having been found in fish caught at Woods Hole and in the Gulf of Maine; but they never take shelled mollusks so far as we are aware, though they bite clam bait as greedily as fish baits, and fishermen speak of them as one of the few species that will bite (that is, which feed) during the spawning period.

Experiments on fish kept in captivity at Woods Hole[68] have shown that the pollock is an excellent visualizer and captures its food by its keen sight more than by scent.

Rate of growth.—Owing to the brevity of its breeding season and to the readiness with which its scales can be "read" European students[69] have found it easy to trace

[67] Smitt. Scandinavian Fishes, 1892.

[68] Herrick. Bulletin, United States Fish Commission, Vol. XXII, 1902 (1904), p. 258.

[69] For resumé see Damas (Rapports et Procès Verbaux, Conséil Permanent International pour l'Exploration de la Mer, Vol. X, No. 3, 1909, p. 167).

the rate of growth of the pollock, and Mavor (1918, p. 111) has done the like for fish caught in the Bay of Fundy. Judging from his data and from the size of the fry caught at Woods Hole in spring, pollock hatched in the Gulf of Maine in midwinter are about 1 to 2 inches long the following spring, growing to 3 to 5 inches by late summer. They will average about 5 or 6 inches by the second spring (their scales then showing one winter ring), about 12 inches the third spring, and 14½ inches by the following midsummer when 2½ years old—that is to say, the little harbor pollock of 6 to 8 inches are in their second summer. Bay of Fundy fish in their fourth summer—that is, when 3½ years old—are 14 to 18½ inches long, and the scales of the few older fish that Mavor examined indicated an average length of about 23 inches at 4½ years, 25 inches at 5½ years, and 27 inches at 6½ years. These sizes are somewhat larger than averages given by Damas for European fish of corresponding ages, but the difference is so small that it is safe to apply the European figures to older Gulf of Maine fish for which Mavor gives no data. Accordingly, we might expect the American pollock to average about 28 inches at 7½ years, about 29 inches at 8½ years, 30 inches at 9½ years, about 31 inches at 12 years, about 32 inches at 13 years, and 33 inches at 14 years. Fish of 3 feet and upward are therefore of a very respectable age, and the oldest recorded by Damas among thousands examined was in its nineteenth year. The annual rate of growth works out to about 6 inches yearly for the first two years, slowing to about 4 inches for the next two or three years. Fish 5 to 10 years old annually increase about 1½ to 2 inches in length, after which they grow still more slowly. In European seas pollock grow faster in the southern part of their range than in the northern part, but whether this applies equally to the American fish is yet to be learned.

The age at which Gulf of Maine fish first mature is not known, but it is probably at the same size as in Norwegian waters, where some may ripen as small as 6 inches, and most of them by the time they are 1½ feet long—that is, 3 years old. All fish of a length of 2 feet and more in summer have spawned at least once.

It may be interesting to note in passing that the relative frequencies of fish of different sizes which Mavor examined point to the year class of 1909 as dominating the catches of Bay of Fundy pollock during 1914, 1915, and 1916.

Breeding habits.—The chief spawning ground for pollock within the Gulf of Maine is at the mouth of Massachusetts Bay, particularly along the outer (eastern) slope of Stellwagen Bank and on the broken bottom southeast of Gloucester. According to Mr. Corliss, superintendent of the Gloucester hatchery, "the bulk of the pollock eggs collected for this [Gloucester] station are taken on the grounds lying 12 to 25 miles southeast of Eastern Point Light, the most prolific ground being 18 miles offshore." The gill-netters also catch an abundance of ripe fish between Cape Ann and the Isles of Shoals, where breeding pollock congregate in such abundance as to support a lucrative fishery.

In some years many pollock spawn, and large quantities of their eggs have been collected for the hatchery, right up to Boston Lightship in the inner part of Massachusetts Bay, though this is not a regular annual event. But few spawning pollock are caught in the Gulf south of the Massachusetts Bay region, and we find no report of it as breeding anywhere west of Cape Cod although fry of the winter's hatch

appear at Woods Hole in spring (p. 405). On the other hand few ripe fish are seen along the coast of Maine, nor have we found pollock eggs anywhere north of the Isles of Shoals in our autumn or winter towings, and as the Boothbay hatchery has made diligent search east of Casco Bay, usually in vain, it is safe to say that no production of any importance takes place between Cape Elizabeth and the Bay of Fundy. Though small bodies of fish may perhaps spawn all along this belt during some years, if not annually, it seems that none do so (or at any rate that no larvæ are hatched) on the New Brunswick side of the Bay of Fundy, for no pollock eggs, larvæ, or young fry have been found there although adults, half grown fish, and even yearlings occur in great numbers. Whether pollock breed along the west coast of Nova Scotia, and in what numbers, is still to be determined, though local fishermen could no doubt answer the question. It is obvious that if no more pollock spawn in the eastern part of the Gulf than present knowledge suggests, the adult fish so plentiful there in summer and autumn must migrate to the southwestward for breeding, but more definite information on this point is to be desired.

The pollock is a late autumn and early winter spawner, with the 1st of November to the middle of January covering the period of most active production for the Massachusetts Bay region, a fact established by many years' experience at the Gloucester hatchery, where many millions of pollock eggs are hatched annually, and illustrated in the following table supplied by C. G. Corliss:

Season	First eggs taken	Last eggs taken	Eggs most plentiful	Total eggs collected
1911–12	Nov. 10	Jan. 22		499, 875, 000
1912–13	Nov. 1	Jan. 31		856, 680, 000
1913–14	do	Feb. 6		974, 240, 000
1914–15	do	Feb. 9		855, 020, 000
1915–16	do	Feb. 17		1, 713, 730, 000
1916–17	Nov. 7	Jan. 27	Nov. 16 to Jan. 20	2, 081, 400, 000
1918–19	Nov. 6	Jan. 23	Nov. 20 to Jan. 8	1, 110, 470, 000
1919–20	Nov. 10	Jan. 16	Nov. 17 to Jan. 16	954, 800, 000
1920–21	Nov. 15	Jan. 21	Nov. 21 to Jan. 16	650, 850, 000

In 1912 the first ripe fish was caught about October 25, and it is unlikely that pollock ever spawn before the middle of that month. Spawning is practically completed by the middle of February, and the first week of March is the latest that the gill-netters have reported spawning fish. With many species of fish odd individuals spawn out of season, but this seems never to happen with pollock, for fishermen never report ripe ones, nor have we towed any pollock eggs, between early March and the following October. The pollock spawns considerably earlier in the Gulf of Maine than in north European waters, where breeding does not begin until January, is at its height in March, and continues into April, the latter month seeing the chief production of eggs about Iceland.

The Gulf of Maine pollock, like the cod and haddock, spawn in comparatively shoal water, the ripe fish that supply the Gloucester hatchery with eggs being netted chiefly in depths of 25 to 50 fathoms, while on November 8, 1916, we towed a considerable number of pollock eggs over Stellwagen Bank where the water was only 16 fathoms deep. Probably few spawn deeper than 50 to 60 fathoms, and there is no evidence at hand either in the form of egg records, captures of ripe

fish, or fishermen's reports, that any pollock eggs are produced in the deep basin of the Gulf. In European waters, however, this fish is described as breeding only in depths greater than 75 fathoms, a difference difficult to account for. Although the pollock is not a ground fish at other seasons, the gill-netters describe it as spawning on hard bottom.

The brief duration of the breeding season and the fact that the vertical temperature gradient then covers a range no greater than 3° to 5° down to 50 fathoms, makes it easy to establish the physical conditions under which the eggs are spawned and in which they develop. On the Massachusetts Bay ground breeding commences when the whole column of water has cooled to about 47° to 49°, and is at its climax (late in December) in temperatures of 40° to 43°, with the major production of eggs taking place long before the water cools to its winter minimum of 35° to 36° at the level at which the fish lie. Thus the pollock spawns on a falling temperature, with most of the eggs produced within a comparatively narrow range and in water several degrees warmer than that in which haddock spawn most actively (p. 442). This agrees closely with the European pollock which, so far as known, spawns only in temperatures closely approximating 44.5°.

The Massachusetts Bay spawning takes place in water as fresh as 32 per mille and as saline as 32.8 per mille, according to precise locality, depth, and season—salinities much lower than those in which pollock breed on the other side of the Atlantic (35.14 to 35.26 per mille), a difference obtaining for almost all species of fish that spawn both in the Gulf of Maine and in north European seas.

As the successful propagation of any fish depends as much upon the incubation of its eggs as on its spawning, we should note that hatchery experience proves that incubation proceeds normally and with the resultant larvæ apparently strong and active over the whole range of temperature just outlined—that is, from about 38° to about 48°. This fact is evidence that regional variations of temperature are not the factor that localizes the breeding pollock in the southwestern part of the Gulf and prevents it from spawning on the north shore of the Bay of Fundy, for the temperature of Massachusetts Bay differs by only a couple of degrees from that of Passamaquoddy Bay at the commencement of the breeding season. While the coastal water as a whole is cooler east than west of Cape Elizabeth at the height of the spawning period, the differences from station to station have been small, and all the readings we have taken during late December and early January have fallen well within the extremes between which pollock spawn freely in Massachusetts Bay, as appears in the following table. This applies equally to salinity.

Water temperatures, Massachusetts Bay to Lurcher Shoal, 1920–1921

Depth, in fathoms	Off Gloucester, Dec. 29, station 10489	Off Cape Elizabeth, Dec. 30, station 10494	Off Mount Desert Island, Jan. 1, station 10497	Off Machias, Jan. 4, station 10498	Fundy Deep, Jan. 4, station 10499	Off Lurcher Shoal, Jan. 4, station 10500
0	42	42	40.5	42	42	42.5
10	43.7	42.5	41.4	42	42.4	42.7
20	44.4	43.1	41.8	42.1	42.6	43.1
40	44.4	44.9	42.3	42.1	42.9	43.9
75	44.6				43.5	

The number of eggs produced by the female pollock varies with the size of the individual fish. The average is about 225,000, but more than 4,000,000 eggs have been found in one fish of 23½ pounds. The egg is buoyant, without oil globule, and averages about 1.15 mm. in diameter. It is thus decidedly smaller than the egg of the cod or haddock. Incubation occupies 9 days at a temperature of 43°; 6 days at 49°. As development proceeds black pigment cells appear along the sides of the embryo and on the adjacent portions of the yolk, and by hatching time these are scattered over the whole surface of the embryo.

The larvæ are about 3.4 to 3.8 mm. long at hatching, slender, with large yolk sac, and sprinkled with black pigment cells, with the vent situated on one side at the base of the ventral fin fold, as it is in other larval gadoids. At first the little pollock float with yolk uppermost but they right themselves as the yolk shrinks. About 5 days' time are required for the entire absorption of the yolk sac and for the formation of the mouth, during which period the pigment of the post-anal section of the trunk becomes grouped in longitudinal bars, two dorsal and two ventral, the former longer than the latter. At this stage pollock closely resemble cod of the same size, but in the latter the ventral bars are longer than the dorsal ones opposite them, and usually three in number instead of two. These bars persist until the pollock grows to a length of about 15 mm., when the pigment becomes more scattered. The caudal fin rays appear at about 9 mm., all the dorsal and anal rays and the ventral fins at about 15 mm., the vertical fins are separate from one another at 20 mm. (that is, at about 2 months), and fry of 25 to 30 mm. show most of the characters of the adult.

In European seas the young pollock lives pelagic near the surface for its first three months, corresponding to which the young fish have been taken in the tow nets at Woods Hole from January to May and are to be expected in Massachusetts Bay then, though we have no actual record of them there. At Woods Hole, furthermore, the fry are about 1½ inches long in April, which no doubt applies equally north of Cape Cod. The later growth has been discussed already (p. 401).

The migrations of the young fish from hatching until they appear on the coast as yearlings are of special interest in the case of the pollock because of the strong probability that the multitudes of these fish, large and small, that frequent the eastern coast of Maine are produced elsewhere, which, if correct, entails a considerable return journey on the part of the young fish. Our own observations throw no direct light on this phase of their lives, but the general circulation of the Gulf suggests that larvæ hatched anywhere along the coast south of Cape Elizabeth would drift southward, either to swing offshore toward the southeastern part of the Gulf, or to follow the shore past Cape Cod. The presence of an abundance of pollock fry in spring at Woods Hole corroborates this, for pollock are not known to spawn anywhere west of the Cape (p. 402).

As the fish grow larger they become able to direct their swimming more effectively, either in pursuit of food or in relation to the prevailing current, but no evidence has yet been gathered as to whether the eastern coast of Maine and the Bay of Fundy draw their abundant stock of pollock chiefly from the spawning grounds of the Cape Elizabeth-Cape Cod region or whether, and in what proportion,

from other spawning grounds along the west coast of Nova Scotia or even east of Cape Sable, as yet unmapped.

Commercial importance.—Appreciation of the value of the American pollock as a market fish is of comparatively recent growth. It is as good as cod salted, if not better, and is a fair fish eaten fresh though it soon softens.

The gill net has proved the most effective apparatus for the capture of pollock. Large numbers are also taken on hand lines and line trawls and they are often seined when in schools (especially the smaller sizes), but otter trawls yield comparatively few, as might be expected of so active a fish and one inhabiting the mid-waters rather than the ground. Pollock can often be caught on the surface by trolling, especially when the current runs strong and when the water is comparatively cool. They will also take a bright-colored artificial fly. This is so strong a fish that it gives almost as good sport on a light rod as a salmon.

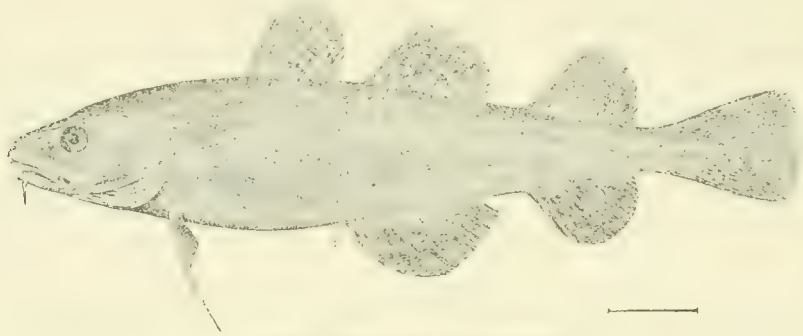

FIG. 203.—Tomcod (*Microgadus tomcod*).

151. **Tomcod** (*Microgadus tomcod* Walbaum)

FROSTFISH

Jordan and Evermann, 1896–1900, p. 2540.

Description.—The tomcod so closely resembles a small cod in the shape of its fins, the projection of its upper jaw beyond the lower, the presence of a barbel on its chin, and in its pale lateral line, that the one might easily be taken for the other. However, the outlines of the ventral fins offer a field mark by which the two fish may be separated, for while their second rays are filamentous at the tip in both species, those of the cod are moderately broad, rounded, and with the filament occupying less than one-fourth the total length of the fin, whereas the ventral of a tomcod is so narrow, so tapering, and with so long a filament (as long as the rest of the fin) that the whole suggests a feeler rather than a conventional fin. Furthermore the margin of the caudal fin of a tomcod is noticeably rounded, while that of the cod is square or slightly concave; the eye of the tomcod is decidedly smaller than that of a cod, and the general form of its body is more slender. A less obvious difference is that the first dorsal of the tomcod originates over or behind the middle of the pectoral, further forward in the cod; and finally, the pectoral fin reaches

back only slightly beyond the middle of the first dorsal in the tomcod while it reaches nearly to the extremity of that fin in the cod. Unfortunately the number of fin rays varies so widely in both these fish that it is not diagnostic, there being from 11 to 15 in the first dorsal, 15 to 19 in the second, 16 to 21 in the third dorsal of the tomcod, 12 to 21 in its first anal and 16 to 20 in its second. In a large fish of about 12 inches we found the number to be 11, 18, and 20 dorsal rays and 21 and 19 anal rays. Most of the recent accounts give the location of the vent as the chief external distinction between tomcod and cod, describing it as in front of the origin of the second dorsal in the former and back of it in the latter. We must caution the reader, however, that it is only for adults of the two species (which no one could confuse in any case, cod being so very much the larger) that this distinction holds, for cod as small as tomcod (that is, up to a foot long) often have the vent well in front of the second dorsal, while on the other hand it may hardly be further forward in adult tomcod in breeding condition.

Color.—Tomcod are not as variable in color as cod. All we have seen (a considerable number) have been olive or muddy green above, with a yellowish tinge, darkest on the back, paling on the sides, and mottled with indefinite dark spots or blotches. The lower sides usually show a decided yellowish cast in large fish. The belly is grayish or yellowish white, the dorsal and caudal fins of the same color as the back, the anals pale at the base but olive at the margin, and all the fins more or less dark mottled. The tomcod has often been described (following Storer) as thickly speckled with black dots, but we have never seen one so marked.

Size.—The maximum length is about 14 inches and few are more than 9 to 12 inches long.

General range.—North American coastal waters from the Gulf of St. Lawrence to Virginia, running up into fresh water.

Occurrence in the Gulf of Maine.—The tomcod is locally common around the entire coast line of the Gulf. For example, it has been recorded from Pubnico [70] and St. Mary Bay on the west coast of Nova Scotia, from various localities on both shores of the Bay of Fundy (e. g., Annapolis Basin and River, Minas Basin, St. John Harbor, and the St. Andrews region), from Eastport and almost every river mouth along the Maine coast. It is very common in the vicinity of Boothbay Harbor, has been recorded from sundry stations in Casco Bay, and from Portland Harbor in Maine, and is to be found in practically every estuary around Massachusetts Bay. It is so strictly a shore fish that probably none wander outside the outer headlands nor descend more than a few fathoms below low tide mark in the Gulf, but chiefly inhabit the mouths of streams and the estuaries into which they empty, as well as shoal muddy harbors like Duxbury Bay. As often as not they are in brackish water and in winter they run up into fresh water. Tomcod are less plentiful in harbors where there is no stream drainage, but now and then they are caught off open shores—off Nahant, for instance—and such fish are usually large. South of Cape Cod these little fish move out from the shore into slightly deeper (hence cooler) water in spring, coming in again in autumn to winter in the estuaries; but they do not carry out a bathic migration of this sort in the cooler Gulf

[70] Huntsman, 1922a, p. 68.

of Maine, where they are caught from docks and bridges and in salt creeks, etc., in summer as well as in winter. Tomcod, for instance, are common in the inner parts of Duxbury Bay in midsummer though most other fish move out then to avoid the heat, and there are also plenty of them in a certain brackish stream at Cohasset at all seasons, which applies to many similar locations all up and down the coast, including the Bay of Fundy, where, as Huntsman (1922a) remarks, tomcod are in the estuaries, not outside, at all seasons. They are so resistent to cold as well as to heat that we find no record of them killed by winter chilling, a fate that sometimes overtakes other fishes living in shoal water, and they are equally hardy toward sudden changes of salinity.

Food.—Tomcod feed chiefly on small crustaceans, particularly shrimps and amphipods, a great variety of which have been found in their stomachs; also on worms, small mollusks, squids, and fish fry. Of the latter Vinal Edwards noted alewives, anchovies, cunners, mummichogs, herring, menhaden, launce, sculpins, silversides, smelt, and sticklebacks in tomcod stomachs at Woods Hole.

According to Herrick [71] tomcod are not as keen-sighted as pollock nor as active as hake, spending most of their time quietly on the bottom in the aquarium; but his experiments proved that they are able to recognize concealed baits by the sense of smell if they chance to swim near, and that they search the bottom, swimming to and fro with the chin barbel and sensitive tips of the ventral fins dragging, finding food by touch, or, as we suspect, to stir up shrimps, etc.

Breeding habits.—This fish spawns in the shoal waters of estuaries, stream mouths, etc.—in salt or in brackish water indifferently—and its eggs have even been hatched artificially in fresh water. The season lasts from November to February, inclusive, with the height of production in January. The eggs are about 1.5 mm. in diameter with conspicuous oil globule, and unlike those of its larger relatives they sink to the bottom where they stick together or to seaweeds, stones, etc., in masses. Incubation occupies about 24 days at an average temperature of 43°; 30 days at 40°. The larvæ are not only considerably larger (5 mm.) at hatching than those of the cod, but further advanced in development, the mouth being formed; and they differ from all other Gulf of Maine gadoids at a corresponding stage by the presence of the oil globule and by the fact that the vent opens at the margin of the ventral fin fold and not at its base at one side.[72] Although great numbers of tomcod have been hatched artificially by the State of New York its late larval stages have not been described nor have we seen them ourselves. The fry, which are said to remain through their first summer in the waters where they are hatched, reach a length of 2½ to 3 inches by the following autumn, but nothing is known of the rate of growth of older fish.

Commercial importance.—The tomcod seems to have been more highly considered as a food fish three-quarters of a century ago, when between 5,000 and 10,000 pounds were caught annually in the Charles River near Boston alone, than it is to-day when 1,000 pounds is a fair average for tomcod brought into Boston annually. In 1919 the reported catch was only about 900 pounds for the west coast of Nova

[71] Bulletin, United States Fish Commission, Vol. XXII, 1902 (1904), p. 262.

[72] Ryder (Report, United States Commissioner of Fish and Fisheries, 1885 (1887), p, 523, Pl. XIII, fig. 67) describes the newly hatched larva.

Scotia, 14,000 for the Scotian shore of the Bay of Fundy, and 8,000 for the New Brunswick shore, 147,160 pounds for Maine, and less than 4,000 pounds for the whole coast line of Massachusetts north of Cape Cod. Most of the tomcod marketed in New Brunswick and Maine are taken in bag or pocket nets set in the lower courses of the larger rivers, and a few in the weirs. The Massachusetts catch is made on hook and line north of Plymouth and in weirs and traps south of that. Besides the fish marketed a considerable number are caught in autumn on hook and line by smelt fishermen all along the shores of northern New England and used for home consumption. Hence they are not reported or included in the fishery statistics.

Tomcod bite any bait greedily. Clams, shrimp, blood worms, or cut fish will serve, and they afford amusement to more anglers than the meager commercial catch might suggest.

152. **Cod** (*Gadus callarias* Linnæus)

ROCK COD

Jordan and Evermann, 1896–1900, p. 2541.

Description.—The most noticeable external characters of the cod, emphasized above in the general notice of the cod family (p. 385), are its three dorsal and two anal fins, the lack of spines, the location of its ventral fins well forward of the pectorals, and the facts that its upper jaw protrudes beyond the lower, its tail is usually nearly square, and that its lateral line is pale and not black. It is a heavy-bodied fish, only slightly compressed, its body deepest under the first dorsal fin (one neither very fat nor very lean will be about one-fourth to one-fifth as deep as long) tapering to a moderately slender caudal peduncle, and with head so large that it makes up about one-fourth the total length of the fish. The nose is conical and blunt at the tip, and the mouth is wide, gaping back to below the middle of the eye, with very small teeth in both jaws. The first dorsal fin usually (if not always) originates well in front of the midlength of the pectoral, is the highest of the three dorsals, triangular, with rounded apex and convex margin. The second dorsal is nearly twice as long as the first and about twice as long as high, decreasing in height from front to the rear with slightly convex margin. The third dorsal is slightly longer than the first and similar to the second in shape. The caudal is about as broad as the

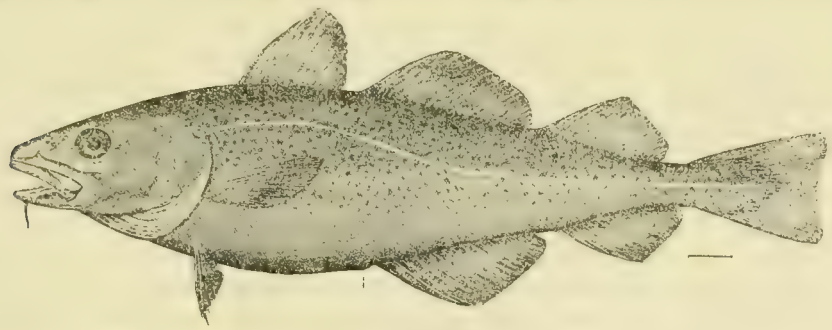

FIG. 204.—Cod (*Gadus callarias*)

third dorsal is long (rather small for the size of the fish) and broom-shaped. The two anals stand below the second and third dorsals to which they correspond in height, length, and outline. In a large series of Gulf of Maine cod 23 to 37 inches long, examined by Welsh, the number of fin rays was as follows:

	Dorsal			Anal	
	First	Second	Third	First	Second
Least	13	19	18	20	17
Average	15	21	19	22	18
Most	16	24	21	24	22

These counts would be equally characteristic for the cod of other seas, but as few as 12 rays have occasionally been recorded for the first dorsal, 16 for the second, 17 for the third, 17 for the first anal and 16 for the second. The pectorals, set high up on the sides, reach as far back as the end of the first dorsal. The ventrals are nearly as long as the pectorals in young cod but shorter in large fish, with the second ray extending beyond the general outline as a filament for a distance almost one-fourth as long as the entire fin. Both head and body are clothed with small scales.

Young cod are easily distinguished from large tomcod by their broad ventral fins and by the location of the first dorsal fin, as explained in the description of that species (p. 406). The pale lateral line marks the cod off at a glance from the haddock, and the square broom-shaped tail, projecting upper jaw, and spotted color pattern of a cod give it an aspect quite different from that of the pollock.

Color.—Cod vary so widely in color that sundry of its color phases have been named, but all fall into two main groups—the gray and the red. The back and upper sides of the former range from almost black through dark sooty or brownish gray, olive gray, olive brown, sepia brown, mouse gray, ashy gray, clay colored, and greenish to pale pearly (darker on the back than on the sides), the fins being of the general body tint, and the belly whitish, usually tinged with the general ground color. The red or "rock" cod varies from dull reddish brown to orange or brick red, with white belly tinged with reddish, and with red, olive, or gray fins. In most cod the upper part of the trunk, the sides of the head, and the fins and tail (but not the nose or belly) are thickly speckled with small, round, vague-edged spots. In the "gray" fish these are of a brownish or yellowish cast, darker than the general body color, while in the "red" fish they are usually reddish brown and sometimes yellowish. Occasionally one sees a spotless cod, but these are unusual. The lateral line is invariably paler than the general body tint—pearly gray or reddish according to the hue of the particular fish in question—and stands out against the darker sides.

Size.—Cod sometimes grow to a tremendous size. A monster of 211¼ pounds, more than 6 feet long, was caught on a line trawl off the Massachusetts coast in May, 1895;[73] one that weighed 138 pounds after being dressed (hence must have "gone" 180 pounds or more alive) was brought in from Georges Bank in 1838; and Goode

[73] Jordan and Evermann. American Food and Game Fishes. 1902. New York.

(et al., 1884) mentions several others of 100 to 160 pounds caught off Massachusetts. Hundred-pounders are exceptional, however, and the largest New England cod of which we have heard recently was one of 90 pounds taken off the coast of Maine early in July, 1922. Even a 75-pound fish is a rarity, but 50 to 60 pound cod are not unusual. The "large" fish caught near shore run about 35 pounds and those taken on Georges Bank about 25 pounds. Shore fish, large and small, average about 10 to 12 pounds in weight.

The relationship between length and weight is usually about as follows for fish caught on the inshore grounds between Cape Ann and Portland, though this varies with the condition of the fish and their state of sexual development.[74]

Length in inches	Weight	Length in inches	Weight
FEMALES	*Pounds*	MALES	*Pounds*
19	2⅛	10 to 11	½
20	3	16½	1¼
21	3⅛	20	3
22	4	21	3¾
23	4½	23	4½
24	5	24	4 to 5½
25	5 to 7	25	5½
26	5¾	26	6¼ to 8
27	7½	27	7 to 8½
28 to 29	7 to 9	28	7 to 8
30	7½ to 9	29	7 to 9
31	8½ to 10	30	7 to 10½
32	9 to 13	31	7 to 11
33	10 to 12	32	10½ to 13
34	12½ to 17½	33	11 to 14
35	14	34	14 to 17
36	16	35	12 to 15
36½	16 to 23	36	12¾ to 16
38 to 39	18 to 22	37	16 to 17
40	16 to 23	38	17 to 21
41	23¾ to 32	39	19
42	27	40	19 to 21½
43	29½	41	25
44	30 to 32	42	23½ to 25
48½	31	43	25½
50	49	45	29
50½	45½ to 51	46	43
52	50		
57½	54		

A 99½-pound fish recorded by Earll was 62 inches long, and one of 100 pounds caught off Wood Island on April 9, 1883, measured 65 inches, its head measuring 17½ inches. Any fish of 5½ to 6 feet will weigh 100 pounds.

General range.—Both sides of the North Atlantic, north to Greenland, Davis Strait, and Hudson Straits and south nearly if not quite to Cape Hatteras on the American coast. Abundant from northern Labrador to Nantucket Shoals, and to New York and New Jersey in winter, at which season a few are annually caught as far south as the northern part of the North Carolina coast. The North Pacific cod, with smaller air bladder (*G. macrocephalus*), can not be separated from the Atlantic cod by external appearance.

Occurrence in the Gulf of Maine.—Next to the herring, haddock, and pollock, the cod is perhaps the most plentiful fish in the Gulf of Maine. From earliest colonial times and until the market began to welcome the haddock a few years ago, cod was the mainstay of its commercial fisheries. We fancy there is no patch of

[74] Based chiefly on measurements given by Earll (1880, p. 734) and on a large series of cod measured fresh from the nets by Welsh in the spring of 1913.

hard bottom, rock, gravel, or sand, from Cape Sable on the east to Cape Cod on the west, but supports more or less cod at one time or another, and to list these localities would be to mention every ground to which deep-sea fishermen repair *except* the soft bottom, where hake are set for. Cod populate the outlying ledges, Jeffreys, Cashes, Fippenies, Platts (the latter one of the best of the smaller grounds), and the larger offshore banks in abundance. The eastern half of Georges Bank, in particular, has always been a most productive cod ground and one of the most famous south of the Grand Banks of Newfoundland. The next largest Gulf of Maine fares are brought in from the South Channel—Nantucket Shoals region in the southwestern part of the Gulf, and from Browns Bank in the eastern part, the latter being especially productive in winter. The broken bottom off Seal Island, Nova Scotia, the ground near Lurcher Shoal, and Grand Manan Bank are all famous cod grounds. Best known among the inshore waters are certain hard patches off Chatham (Cape Cod), between Provincetown and Plymouth and off the latter port, Jeffreys Ledge off Cape Ann, and Ipswich Bay. Small vessels likewise make good catches on the succession of hard and rocky patches that border the coast from the Isles of Shoals to the mouth of Casco Bay; on "Seguin" and "Kettle" bottoms off Seguin Island; on the "Matinicus ground" off Matinicus Island; on the "Grumpy" off Isle au Haut; in the neighborhood of Mount Desert Rock and of Mount Desert Island; and on sundry small ridges thence eastward to the mouth of the Bay of Fundy. Many smaller spots all up and down the coast yield a few cod to the small-boat fishermen, also.

The following statement of the landings of fresh cod from several of the more important Gulf of Maine grounds for 1919 will serve to illustrate the relative productivity of the grounds and the great commercial importance of the cod:

Locality	Pounds
Georges Bank	22, 387, 191
Browns Bank	9, 337, 777
South Channel	5, 164, 589
Jeffreys Ledge	875, 414
Off Chatham	619, 020
Stellwagen Bank	388, 135
Platts Bank	341, 698
Nantucket Shoals	250, 880
Cashes Ledge	13, 015

The catch on the small inshore fishing grounds off the coasts of Massachusetts and Maine by large vessels and small boats combined came to a total of almost 20,000,000 pounds for that year, while nearly 2,000,000 pounds more were caught on the New Brunswick side of the Bay of Fundy, mostly close by its mouth west of St. John, and almost 6,000,000 more off the Scotian shore of the Gulf, which includes most of the catch made on the Lurcher Shoal, Seal Island, and German Bank grounds and some from Browns Bank. This makes a grand total of upwards of 67,000,000 pounds (say 6,000,000 fish) for 1919, a fairly representative year. Nor is this a complete survey of the Gulf of Maine, for it does not include the considerable number of fish caught on Browns Bank by vessels hailing from various ports on the south coast of Nova Scotia.

Cod, for some reason not yet explained, become scarcer passing up the Bay of Fundy, and very few are caught near the head, though there are plenty about its mouth. Although cod are fish of the open sea in other parts of the Gulf, they often run up into the estuaries during the cold season, appearing regularly in various river mouths in Maine and Massachusetts during late autumn and winter. It is rare for one to be taken in brackish water, and although cod have been caught in

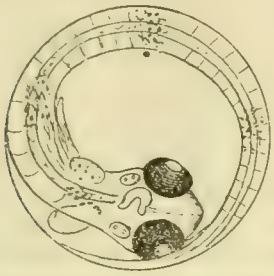

FIG. 205.—Egg (European). After Heincke and Ehrenbaum

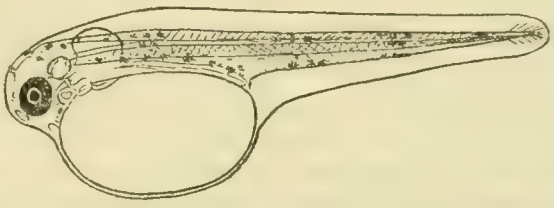

FIG. 206.—Larva (European), just hatched, 4 millimeters. After Mastermann

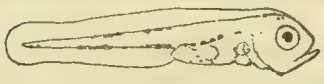

FIG. 207.—Larva (European), 4.5 millimeters. After Schmidt

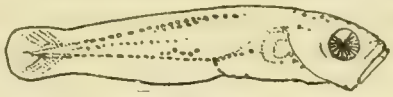

FIG. 208.—Larva (European), 9 millimeters. After Schmidt

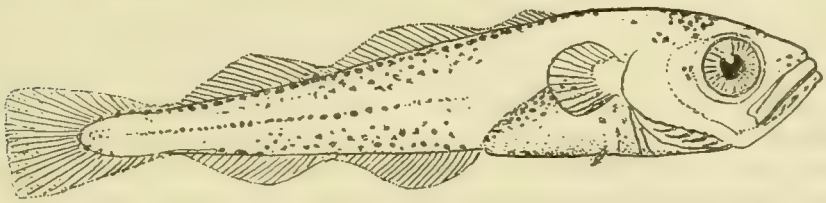

FIG. 209.—Fry (European), 20 millimeters. After Schmidt

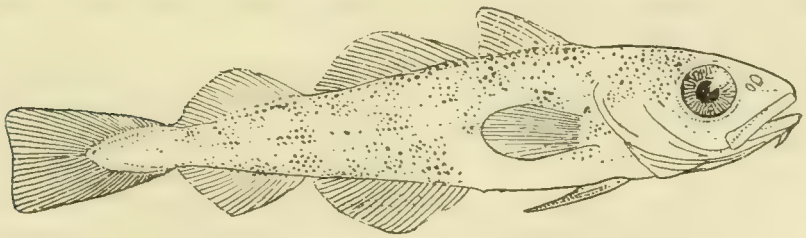

FIG. 210.—Fry (European), 46 millimeters. After Schmidt

COD (*Gadus callarias*)

fresh water,[75] this is quite exceptional. The continental slope marks the offshore boundary to the range of the cod off the North American coast.

Habits.—The cod is catholic in its choice of depth, ranging from the surface down to at least 250 fathoms off New England; but it is only in pursuit of small fish or squid that adult cod come to the top of the water—a common event on the

[75] Goode (et al., 1884) mentions several instances.

Grand Banks and along the eastern coast of Labrador when they are following capelin. Cod even strand on the Labrador beaches while harrying schools of the latter, and occasionally, though less often, cod follow herring up to the surface in the Gulf of Maine, though perhaps they never strand there. For instance, we have known large cod to be gaffed from a vessel's side in Northeast Harbor, Mount Desert Island, in September, when they were chasing "sardines."

During the first year after the young cod take to bottom (p. 417) many of them live in very shoal water, even along the littoral zone, and many young fry have been taken at Gloucester and elsewhere along the shores of New England. We have yet to learn, however, whether others seek the deeper bottoms of the offshore banks at this early stage. As a rule large cod lie below 10 fathoms in summer. In winter time, however, especially in Ipswich Bay, the fishing is often good in only 3 to 5 fathoms of water, and many small cod are caught about the rocks only a fathom or two deep even in summer. At the other extreme, comparatively few cod are caught much deeper than 100 fathoms in the Gulf of Maine, and although fishermen sometimes do well at much greater depths on the slopes of the offshore banks, the 10 and 75 fathom contours probably include the great majority of all the cod living in the Gulf, summer or winter.

The cod is typically a ground fish except when following prey or on some journey (a subject to be discussed later), usually lying within a fathom or so of the bottom, and as a general rule large ones keep closer to the ground than small ones, and consequently the closer to bottom one fishes the larger the cod are apt to run.

Type of bottom frequented.—Cod are caught chiefly on rocky and pebbly ground, on gravel, sand, and on a particularly gritty type of clay with broken shells—seldom on soft mud—"cod" and "hake" bottoms being so distinct that a trawl line set from a hard patch out over the soft surrounding ground will often catch the former at one end and the latter at the other. Cod also frequent the deeper slopes of ledges along shore where they forage among the "Irish moss" (*Chondrus crispus*) and other seaweeds. Young ones are especially common in these situations and sometimes one catches a large "rock cod," as these fish (almost always red in such environments) are called.

The thermal migrations and the relationship of the spawning of the cod to temperature are discussed below (p. 418). The adult cod finds any temperature from 35° to 50° favorable—that is, all but the superficial layers of the Gulf of Maine at all seasons. Experience at the Woods Hole hatchery, however, proves that freezing, by the formation of anchor ice, for instance, is fatal. Large cod do not live anywhere in water warmer than about 50°, but small ones are less sensitive to heat, a fact reflected in their bathic occurrence.

Food.—When the larval cod first breaks from the egg it subsists on the yolk with which its abdomen is distended (fig. 206), as do most other sea fish. This source of nutriment is completely absorbed by the sixth day after hatching, however, and the future existence of the little fish depends as much on finding a plentiful supply of food as on escaping the enemies by which it is encompassed. Unfortunately little is known of the feeding habits of the larvæ, but it is certain that they feed on plankton during the several months that they live in the upper layers of

water (p. 417), probably preferring certain small copepods, on which young cod of 12 to 18 mm. have been seen feeding exclusively at Woods Hole.[76]

The fact that the young of the closely related European whiting (*Gadus merlangus*) and European pollock (*Gadus pollachius*) not only live almost wholly on copepods but discriminate between the various kinds makes it the more likely that cod do the same. This same diet, varied with amphipods, barnacle larvæ, and other small crustaceans, as well as with small worms, is the chief dependence of the little cod when they first seek the bottom,[77] but as they grow larger they become ground feeders chiefly and consume invertebrates in great variety and enormous amount. Mollusks, collectively, are probably the largest item in the cod's diet in the Gulf of Maine, and any shellfish that a cod encounters is gobbled up, so that cod stomachs are mines of information for students of mollusks. Large sea clams (Mactra), the empty shells of which are often found neatly nested in cod stomachs, cockles (Lunatia), and sea mussels (Modiola) are staples, all of which they swallow whole. Cod also eat crabs, hermit crabs, lobsters (large and small), prawns, brittle stars (of which they are sometimes crammed full [78]), sea urchins, sea cucumbers, and blood worms (Nereis). Brittle stars and small crabs, for example, had been the chief diet of the cod examined by Welsh on the Isles of Shoals-Boon Island ground in April, 1913, while Wilcox (1887, p. 95) states that a number of 17-pound fish caught in Ipswich Bay were full of large red prawns 2 to 4 inches long. Tunicates ("sea squirts") also bulk large in the diet of the cod. Occasionally they eat hydroids, bryozoans, and algæ, perhaps taking them for the amphipods hidden among them. In fact the cod eats any and every invertebrate small enough for it to swallow, but although its diet list would probably prove almost as extensive as that of the haddock (p. 436), it shows so decided a preference for large shells rather than small that the stomach contents of cod and haddock taken side by side differ noticeably. Nor is it likely that cod root the bottom as haddock do (p. 436).

At every opportunity cod pursue and gorge on squid and on various small fish, particularly on herring and launce, also shad, mackerel, menhaden, silversides, alewives, silver hake, young haddock, and even on their own young, rising into the upper waters for this purpose when necessary (p. 413). They pick up flounders, cunners, rock eels (Pholis), blennies, sculpins, sea ravens, small hake, skates, and silversides on bottom. In fact they take any fish small enough to swallow, including the hard slim alligatorfish (p. 334), and Welsh noted that many cod taken near the Isles of Shoals on May 1, 1913, spat up small rosefish from 4 to 6 inches long. Adult as well as small cod are also known to feed on pelagic shrimps [79] in the waters around Iceland, but we have never heard of them doing so in the Gulf of Maine. Even a wild duck does not come amiss to a large cod now and then. For instance, we have heard of several scoters found in the stomachs of large fish caught off Muskeget Island in 1897, and though sea fowl are not a normal article

[76] Bumpus. Science, New Series, Vol. VII, 1898, p. 485.

[77] McIntosh and Mastermann (The Life-Histories of the British Marine Food-Fishes, 1897) and Kendall (1898, p. 179).

[78] Baird (1889, p. 36) reports this.

[79] Schmidt (Skrifter Udgivne af Kommissionen for Havundersøgelser, Nr. 1, 1904, p. 70) and Paulsen (Meddelelser fra Kommissionen for Havundersøgelser, Serie: Plankton, Bind I, Nr. 8, 1909, p. 39).

of diet the flesh of the greater shearwater ("hagdon") has long been considered excellent cod bait. Objects as indigestible as pieces of wood and rope, fragments of clothing, old boots, jewelry, and other odds and ends have repeatedly been found in cod stomachs, and they often swallow stones, but probably for the sake of the anemones, hydroids, etc., growing thereon, and not to take on ballast for a journey as the old story has it. Although cod are so rapacious they fast so generally while spawning that the stomachs of nearly all the ripe fish examined by Earll and recently by Welsh were empty.

It is not surprising that a fish as nearly omnivorous as the cod is caught on various baits. Those most in use are clams (*Mya arenaria*), cockles (Lunatia), herring (fresh, frozen, or salt), and squid. General experience suggests that there is little to choose between the first two, while the razor clam (*Ensis directus*) is equally attractive though its employment is limited by the small supply; and tests made in the Gulf of St. Lawrence [80] proved that fresh herring and fresh squid are about as good as clams, but frozen or salt herring is less attractive. Other kinds of fish are also used as cod bait in other parts of the world—capelin, especially in more northern seas, and launce.

Experiments performed on the cod in captivity,[81] combined with the general experience of fishermen, suggest that it captures moving objects that may serve as food by sight; but apparently cod, and for that matter other fish as well, can see clearly only for a few feet, and their greediness in snapping up the naked meat of clams, cockles, etc. (foods which they never find in that condition in nature), and the fact that they bite as readily by night as by day, seems to us sufficient evidence that they depend largely on smell.

Enemies.—In the Gulf of Maine, where there are few large sharks or seals, the spiny dogfish is the worst enemy of the adult cod, and that of young cod fry is the pollock which infest our harbors. These small pollock are so fierce that a single individual 7 to 8 inches long will disperse a school of hundreds of cod fry, driving them to shelter among the weeds and rocks, while Earll remarks that in the aquarium a cod so fears a pollock of equal size that it will invariably hide if possible.

Migrations.—It has long been known that cod carry out extensive migrations, European (particularly Scandinavian) biologists having succeeded in tracing the major outlines of these for north European seas, and while the movements of cod are not well understood in North American waters enough evidence has been accumulated to show that they fall into the same categories on the one side of the North Atlantic as on the other. These are, first, the involuntary migrations carried out by the larvæ while they float near the surface at the mercy of ocean currents, followed (after they take to bottom) by feeding migrations that cover most of the wanderings of the immature fish as well as those of the adults between successive breeding seasons, and which are intimately connected with the thermal migrations (for it is in pursuit of food that cod may spread at one season to a region

[80] Knight. Contributions to Canadian Biology, 1906–1910 (1912), pp. 23–32. Ottawa.

[81] Bateson. Journal, Marine Biological Association of the United Kingdom, New Series, Vol. I, 1889–90, p. 241. Plymouth.

whence they are driven by extremes of heat and cold at another); and third, the breeding migrations, in the course of which the mature fish congregate in certain localities to spawn.

The eggs, larvæ, and young fry of the cod, like those of so many other sea fishes, drift helplessly with the current from the time they are spawned until they seek the bottom (a fact established by European observations too numerous to list), and in European seas young cod often live under the disks of the large red jellyfish (Cyanea), though they have not yet been found in this situation in the Gulf of Maine. This period varies in different in different seas, depending to some extent on whether the fry are near land or far out at sea, floating over deep water or shoal; and while no definite information has been obtained on this point for the Gulf of Maine, it is probable that most of the fish hatched on the inshore spawning grounds sink when not over two months old or an inch long, for they are in water so shoal that the bottom is within easy reach. During this involuntary migration the young cod tend to follow the general coast line of the Gulf from northeast to southwest, either to swing offshore toward the southeast part of the Gulf and so to Georges Bank, or to circle around toward the coast of Nova Scotia and the Bay of Fundy. Our few captures of pelagic cod fry have all been in the southwestern part of the Gulf, in which they agree with haddock, silver hake, and most of the common flatfishes; while it is probable that the fry taken in tow nets at Woods Hole in March, April, and May have worked inshore thither from the spawning grounds on Nantucket Shoals. Furthermore, the general eddylike circulation of the Gulf suggests that some of the larvæ hatched on Georges Bank may reach the Bay of Fundy region and the eastern Maine coast before they take to bottom. Others of them, however, may seek the deeper bottom of the offshore grounds, near which they were perhaps produced.

Little is known of the life or wanderings of the cod in the Gulf of Maine from this stage until it is large enough to be caught on hook and line—say 2 or 3 years old. Such of them as come into very shoal water at first gradually work out again into deeper as they grow, their later journeyings largely taking the form of feeding migrations in search of food; and although it seems that small cod do not travel as much as large ones do, they wander sufficiently to populate the entire coast line of the open Gulf including the outer part of the Bay of Fundy, where there are cod of all sizes from yearlings on though none are hatched there (p. 426). Similarly, the investigations of 1913 proved that there are about as many little cod (less than 1 pound in weight) as large on Georges Bank and in the South Channel.

Some bodies of cod wander more than others, and two groups are generally recognized by Gulf of Maine fishermen—the "shore" or "ground" fish and the "school" fish. The former apparently remain throughout the year on rocky patches near land, feeding on the bottom, and they probably travel very little out of spawning time except as they gradually exhaust the food supply in one spot and are therefore driven to move on to fresh pastures. Such fish are usually dark and dull colored, with large heads, and feed chiefly on bottom. The red fish that haunt the rocks belong to this category, and while as a rule these are immature fish that lose their red color as they grow larger, a red "rock" fish as large as 10 or 20 pounds is sometimes caught.

The general opinion is that the "school" fish, which compose the greater part of the local stock of cod, are constantly on the move in loose groups, feeding along over the bottom of their chosen bank and constantly moving on as they exhaust the richest food. Though cod can hardly be described as "schooling" in the same sense as herring or mackerel school, these armies of fish often hold together so closely that it is common enough for one-half of a line trawl to come in loaded with cod with the other half empty. It is these "school" fish which most often prey upon fish and squid, though, like all cod, they feed chiefly on shellfish. They run slenderer and lighter colored than the "ground" cod, with smaller heads, but in all probability such differences are but temporary, reflecting the surroundings of the individual fish and its mode of life at the time. A cod that is a "ground" fish this month may start on its travels next, turning brighter and becoming more shapely as it goes, either through a change of diet, the change of surroundings, or more active exercise.

Fishermen have known from time immemorial that bodies of cod undertake extensive journeys with no apparent cause, suddenly deserting grounds where they were plentiful to appear on other banks often far distant, and it is probable (but not yet proven) that some interchange takes place from one bank to another and between the offshore and inshore grounds. Furthermore, cod may flee a given locality if too much harrassed by the spiny dogfish (p. 48), and no doubt other enemies as well drive them at times, while the oft quoted discovery of hooks of a kind used by the French fishermen on the Grand Banks of Newfoundland [82] in cod caught in Ipswich Bay near Cape Ann is proof that at times they undertake much more extensive migrations and perhaps do so oftener than is suspected, though by what impulse they are driven is not known.

When cod are on their travels they often desert the bottom for the mid-depths (a fact proven by the level at which they are caught in nets), and netted fish are so often empty while those caught on hook and line are full of food that they are popularly (and perhaps rightly) believed to fast while on a journey. It is, we believe, indisputable that cod usually congregate in denser bodies when traveling than when feeding, bodies running very even in size, color, and shape, suggesting that they may preserve their identity for long periods but are mixed as to sex, sometimes males and sometimes females predominating.

Thermal migrations.—In the extreme northern and southern fringes of its geographic range the cod carries out regular seasonal migrations; that is, it is "migratory" in the common understanding of the term. Thus it is only in summer and early autumn that they visit the waters of the polar current along the eastern coast of Labrador, withdrawing again to the south or to deep water for the winter and spring. On the other hand they appear only as autumn, winter, and early spring visitors along the coasts of southern New England, New York, and New Jersey, though in numbers sufficient to support a lucrative fishery (the annual catch of cod between Nantucket and New Jersey may reach 2,000,000 pounds). Between these extremes—that is, from the Grand Banks to Cape Cod—cod are resident to the extent that they are to be found in one locality or another the year round, but

[82] Earll (1880) and Kendall (1898, p. 178) give instances of this.

even in the Gulf of Maine large cod shift their range in depth with the seasons, coming up into shoal water in autumn and winter as the temperature cools and sinking deeper again in spring when the surface warms.

Breeding migrations.—With the first ripening of the sexual products the feeding and thermal migrations are annually interrupted by concentration on certain rather definite spawning grounds, which for the larger fish involves a journey inshore or to the shoaler part of the banks, and the breeding and thermal migrations are combined in the case of those cod that winter west of Nantucket.

Tagging experiments.[83] —It is not known whether individual cod return year after year to spawn on any particular ground or whether they may visit one region in one season and another the next, nor has any attempt been made to trace the lines of dispersal which they follow in the northern parts of the Gulf of Maine when they are spent and recommence feeding. Apparently, however, tagged fish released at

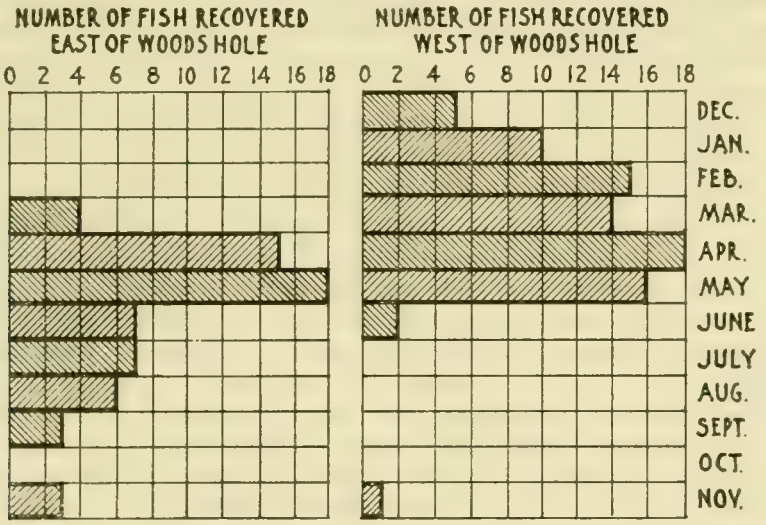

FIG. 211.—Numbers of tagged cod released at Woods Hole in 1898–1901 that were subsequently recovered east and west of that point in different months

Woods Hole after they had spawned (4,000 of them were liberated from December to February of three successive years [84] and 4 per cent were recovered), moved west at first, for a number were retaken along the southern shores of New England and of New York during December and January, while half a dozen were reported from New Jersey, but not one east of Woods Hole until March 27. In April and May, however, tagged fish were reported east of Woods Hole as well as west, and it was during these two months that most of the recoveries were made, chiefly off Rhode Island and New York and on Nantucket Shoals. While reports were received from the latter ground and from off Cape Cod at intervals until September, June 10 was the latest date west of Woods Hole. Unfortunately the tagged fish were all more or less emaciated as the result of a stay of some weeks in the pool followed by artificial

[83] Many experiments of this sort have been made in European waters.

[84] Smith (1902) gives a full account

stripping, and the locality of liberation was at a considerable distance from their normal spawning ground on Nantucket Shoals, hence it is a question how closely their travels represent those carried out by fish spawning there naturally. However, the results were so consistent, one with another, as to warrant the working hypothesis that at least a part of the great body of fish spawning on the shoals works westward along the shores of southern New England during the late winter after they have spawned out, returning again by the same route in spring, many of them to revisit Nantucket Shoals and some to enter the Gulf of Maine, for recoveries were made off Chatham and rumors of tagged fish were received from Maine and Nova Scotia. The fact that one tagged cod was recaptured off Cape Judith, R. I., in a spent condition during the second May after its release, that is, while returning from its second migration to the southward, also corroborates this.

Further investigations along this line promise such interesting results from the fisheries standpoint that between 7,000 and 8,000 cod were tagged and released by the *Halcyon* on Nantucket Shoals from April to October, 1923. Up to January 24, 1924, 163 of these fish had been recovered, and the localities of recapture corroborate in a striking way the westerly winter migration just outlined, for one fish was reported from New Jersey in October, and during November, December, and January 48 were reported from Rhode Island, Long Island, and New Jersey.

Other interesting features appearing from the reports so far received are that most of the fish appear to have remained all summer within a very few miles of the spot on Nantucket Shoals where they were tagged and released, because all the summer recoveries (107) were from that region, except for a few off Cape Cod and off Cape Ann and the one New Jersey fish just mentioned, the most striking instance of this being fish No. 231, tagged on the Shoals June 28, recaptured by the *Halcyon* close by on October 3, and again on October 15. Apparently no migration to the eastward took place during the summer, because not a single fish was recaptured on Georges Bank, notwithstanding the intensive fishing carried on there.

The fact that cod may carry out extensive journeys (the larvæ involuntarily, but the adults under some directive stimulus, sexual or feeding) raises the possibility that the maintenance of the cod stock of the Gulf of Maine depends as much on immigration around Cape Sable as on the reproduction that takes place locally (p. 422), productive though the latter may be. This whole question—and especially the routes followed and distances traveled by the larvæ while afloat—is one of the most interesting problems now facing the Bureau of Fisheries in its study of the natural history of North Atlantic food fishes.

Rate of growth.—So far as we are aware the growth of cod fry for the first few months after hatching has only twice been followed by direct observation in America. The first observations were made in 1898, when a large school of newly hatched larvæ was released in December at Woods Hole in the "eel pond" (a lagoon freely communicating with the harbor and with a temperature about paralleling that of the outside water), where they grew to an average length of 50 to 100 mm. by the following June.[85] The experiment was repeated in the winter of 1899[86] with similar

[85] Bumpus. Science, new series, Vol. VIII, 1898, p. 852.
[86] Smith. Bulletin, United States Fish Commission, Vol. XIX, 1899 (1901), p. 307.

results, as appears from the following table showing the growth of approximately 2,000,000 freshly hatched larvæ placed in the pond on January 11.

Date	Extreme length	Average length	Date	Extreme length	Average length
	mm.	*mm.*		*mm.*	*mm.*
Apr. 8	29 to 38	32.9	May 25	28 to 68	64
Apr. 25	34 to 49	40	June 6	71 to 76	75.5
May 13	35 to 51	42.8	June 20	73 to 77	75

Captures of young fry 1½ to 3 inches long in the neighborhood of Cape Ann late in June (Earll, 1880) shows that cod hatched from January to March in the Gulf of Maine grow at about this same rate, but fish hatched in the rising temperatures of spring might be expected to grow faster during their first few months. Dannevig,[87] in fact, had young cod hatched on April 26 reach an average length of 8.5 cm. by mid September (5 months) and 11.5 cm. by mid October. In general, European experience[88] is to the effect that young cod are 4¾ to 8 inches long by the end of the first autumn, the earliest (winter) hatched being largest, the spring hatched smallest, which probably applies equally to the Gulf of Maine.

In later life cod grow at varying rates in different seas, and even fish caught in the same haul may have grown at very different rates, as the structure of the scales shows. Consequently the length of a fish older than a yearling is no criterion to its age within two or three years. Wodehouse's (1916, p. 103) studies on cod caught at the mouth of the Bay of Fundy suggest that they grow much more rapidly in the Gulf of Maine than anywhere in European waters, as follows:

Age, in years	Length, in inches		
	Bay of Fundy		European
	Average	Smallest	Approximate average
1	5.7	2.4	5
2	14.2	6.4	8.3
3	19.6	12	12.2
4	25.6	14.4	15.4
5	32.3	17.6	18.5
6	35.6	26	21.3
7	39.1	36.4	24
8	45.3	38	26.8
9	[a] 48.8	44.4	29.1

[a] Two fish only.

[87] Canadian Fisheries Expedition, 1914–15 (1919), pp. 1–49.

[88] Damas (Rapports et Procés-Verbaux, Conséil Permanent International pour l'Exploration de la Mer, Vol. X, No. 3, 1909) gives a full account of the European investigations on the life of the cod up to that date.

The fact that cod run much larger in the Gulf of Maine than in either the North Sea or the Norwegian Sea, and that the monsters of 75 pounds and heavier that are brought in every year from our coastal waters are unusual on the other side of the Atlantic, tends to corroborate Wodehouse's age estimates, but the desirability of further investigation along this line is self-evident. Should it finally prove that it is characteristic of Gulf of Maine fish to grow faster than European the inference is obvious—our waters provide a more favorable environment, probably for food.

Judging from the table the general run of mature shore cod caught in the Gulf of Maine (5 to 20 pounds) are 3 to 6 years old, but whether the very large fish occasionally caught have grown exceptionally rapidly or are many years old, remains to be learned.

The smallest ripe male recorded for American waters weighed about 3½ pounds; female 4 pounds[89]—that is, were in their fourth winter —and probably all cod mature in their fifth year.

Breeding habits.—Thanks to Earll's painstaking studies and to the large scale on which the Bureau of Fisheries has subsequently collected and hatched cod eggs at the Gloucester and Woods Hole hatcheries, the spawning season and the major spawning grounds of the cod are fairly well established for the coastal waters between Nantucket Shoals and the Bay of Fundy.

It has long been known that while cod spawn chiefly in winter, both in American and in European waters, the breeding season lasts much longer and is less definitely limited at either end for this species than for the haddock or pollock, and experience has shown that great local differences obtain in the season when the production of eggs is most active even within the comparatively small area now under discussion. For example, W. H. Thomas, superintendent of the Woods Hole station, informs us that the brood fish taken off Nantucket and brought in to the Woods Hole pool spawn there from about the first of December until well into February and occasionally as late as March, but with the major production usually from December 20 to January 7, and he writes that cod "spawn from as early as November 1 until April in the waters off Nantucket; mostly, however, from about January 15 until mid-February." The season is about the same as this off Plymouth in Massachusetts Bay, this being a ground long utilized as a collecting field for the hatcheries, and where, according to data furnished by C. G. Corliss, superintendent of the Gloucester hatchery, ripe cod of both sexes are common from November until as late as April. On the north side of Cape Ann, however, only 50 miles distant, ripe fish seldom appear in any numbers until January and some years not until February, though odd ones may be expected from November on. Earll, for example, found that not one female in ten had commenced to throw her eggs by the latter month in Ipswich Bay, though spawning was then at its height in Massachusetts Bay, nor were as many as 50 per cent of the Ipswich Bay fish ripe before mid-March. Commencing to spawn later there and near Cape Ann than off Plymouth, they also continue to do so considerably later—that is, until the end of April or even

[89] Earll, 1880

the first part of May, as appears from the following table of cod-egg collections supplied by the Gloucester hatchery:

Season	Collecting field	Number of eggs secured	Spawning season
1911–12	Plymouth	67,032,000	Nov. 24 to Jan. 3.
1911–12	Rockport (Ipswich Bay)		Jan. 20 to Mar. 1.
1912–13	Off Rockport (Ipswich Bay)	170,840,000	Feb. 16 to Apr. 7.
1913–14	Off Gloucester	91,980,000	Feb. 1 to Apr. 15.
1914–15		82,460,000	
1915–16	In Ipswich Bay and off the New Hampshire coast	145,630,000	Feb. 9 to Apr. 13.
1916–17		92,340,000	Feb. 27 to Apr. 13.
1917–18	Off Gloucester	119,020,000	Feb. 25 to Apr. 27.
1918–19	do	249,510,000	Feb. 27 to Apr. 30.
1919–20	do	570,740,000	Dec. 28 to Apr. 30.
1920–21	do	210,040,000	Jan. 15 to Apr. 29.

Mr. Corliss further comments as follows regarding the season of 1920:

From January to late in the spring there was one of the largest schools of spawning fish on the inshore fishing grounds ever known to present-day fishermen.

Off the western coast of Maine, according to Capt. E. E. Hahn, superintendent of the Boothbay Harbor hatchery, cod spawn from late February or early March until the last of May, with the production of eggs at its peak in March, and from March through May off the eastern Maine coast, while cod eggs (and hence spawning cod) have been recorded in spring in the Bay of Fundy. Thus it appears that the cod spawns later and later in the year, following around the coast of the Gulf of Maine from south and west to north and east.

On Georges Bank cod spawn in abundance in February,[90] March, and April, and almost as many cod eggs as haddock eggs were fertilized there by the spawn takers of the Bureau of Fisheries during the two latter months in 1919. It is not known whether or in what abundance cod resort to Browns Bank for spawning.

The records of the hatcheries just summarized tell when eggs are produced in maximum abundance, but they throw little light on the limits of the spawning season, for it is only during the period when ripe fish appear in numbers sufficient to warrant the effort and expense that spawn taking is carried on on a large scale, and with cod more than with any other gadoid occasional ripe individuals of both sexes are seen long before and long after most of the other fish breed. Thus Earll (1880, p. 713) writes that the first ripe female was taken near Cape Ann on September 2 during the season of 1878–79, and that ripe fish, both males and females, were occasionally caught thereafter. We have taken cod eggs, far enough advanced in incubation for positive identification as such, off Shelburne (Nova Scotia) on September 6, near Mount Desert on the 15th, and off Penobscot Bay on October 6 (all in 1915). On the other hand Earll saw ripe fish as late as June, proving that cod spawn more or less for nine months of the year about Cape Ann. Our tow-nettings also suggest that some may even spawn in midsummer in the coastal zone east of Cape Elizabeth, for among considerable numbers of eggs of the appropriate size, but freshly spawned, and hence as likely to belong to the witch

[90] This fact has long been common knowledge, and W. F. Clapp, formerly of the Museum of Comparative Zoology, has seen many cod with running eggs caught on Georges Bank in February and March.

flounder as to any gadoid (p. 429), we have occasionally found older ones identifiable as either cod or haddock by the black pigment, and probably as the former. The localities and dates in question are near Mount Desert Island, July 19 (station 10302), near Wooden Ball Island at the mouth of Penobscot Bay, August 6, and near Cape Elizabeth, September 20 (station 10319). Such summer breeding, however, is merely a sporadic occurrence comparable to the so-called "after-spawning" of cod observed off the north coast of Iceland by Schmidt [91] and in the North Sea and the Baltic.[92]

It is not so exceptional for cod to breed in summer off the outer coast of Nova Scotia where ripe fish are reported by local fishermen in June and July, a report which Captain Hahn informs us he can corroborate from personal experience. Similarly, spawning cod were caught from the deck of the *Grampus* (Capt. E. E. Hahn in command) on Bradelle Bank in the Gulf of St. Lawrence late in August many years ago, while gadoid eggs (probably cod) were towed at various localities there during June, July, and August of 1915 by the Canadian Fisheries Expedition,[93] and on the Grand Banks, where practically Arctic temperatures prevail during the spring, cod spawn chiefly if not altogether in summer.

Spawning grounds.—The spawning grounds of the Gulf of Maine cod may be classified as offshore and inshore, the former comprising Georges Bank and Nantucket Shoals (probably also Browns Bank, though we have no actual record of spawning cod there), and the latter the various smaller grounds near the coast between Cape Cod and Nova Scotia. According to the reports of fishermen and to W. F. Clapp's first-hand experience, large schools of cod spawn on the eastern part of Georges Bank east of the shoals, centering at about latitude 41° 21′ to 41° 30′, longitude 66° 50′ to 67° in about 35 fathoms of water, though by all accounts their stay is short, this particular body of cod spawning out and scattering by the 1st of March. It is a striking commentary on our ignorance of the life histories of even our commonest fishes that no data better than vague rumors are at hand as to where and when cod spawn on other parts of Georges Bank, or even whether they do so at all. In all probability, however, they spawn there wherever the water is shoaler than 30 fathoms.

The broken bottom east and south of Nantucket Island, known as Nantucket Shoals (fig. 212), has long been known as a center of abundance for ripe codfish in late autumn and early winter (p. 422), and it is here that most of the brood fish have been collected for the Woods Hole hatchery. Cod with sexual organs in an advanced stage of development appear first on the more easterly of these small banks from late October on, working westward as the season advances. But according to local fishermen they abandon the shoaler (7 to 10 fathoms) portions of these grounds after the water is chilled by the first heavy snows, to congregate from January until April in the two deeper (12 to 20 fathoms) channels close in to Nantucket Island, as is represented on the accompanying chart (fig. 212).

[91] Rapports et Procés-Verbaux, Conséil Permanent International pour l'Exploration de la Mer, Vol. X, 1909, p. 21, 123.

[92] Ehrenbaum (Nordisches Plankton, Band I, 1905–1909, p. 225) and Fulton (Conséil Permanent pour l'Exploratipn de la Mer, Publication de Circonstance, No. 8, 1904).

[93] Dannevig. Canadian Fisheries Expedition, 1914–15 (1919), p. 22.

So far as we can learn few if any cod spawn on the sandy bottom along the outer shores of Cape Cod, but great numbers of ripe fish congregate in Massachusetts Bay on well-defined grounds 3 to 10 miles offshore, extending from abreast of

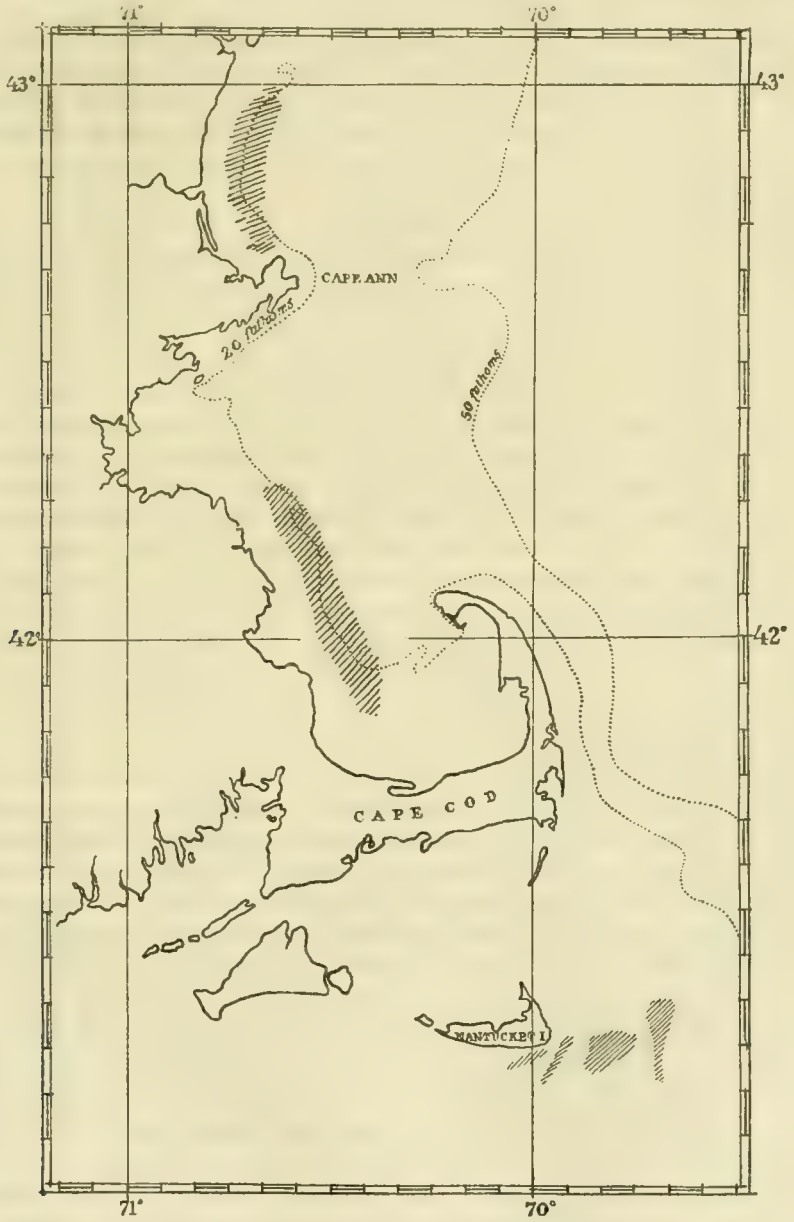

FIG. 212.—Chief spawning grounds of cod in the western side of the Gulf of Maine

Sandwich (some 12 miles south of Plymouth) to Minots Light. A few breed on various small rocky patches off Gloucester. Years ago many cod also spawned over a small area off Boston Lighthouse and thence northward toward Bakers

Island, but few breeding fish have been found there of late, probably because this particular locality has been selected as the dumping ground for the refuse from Boston.

The Ipswich Bay region, where large schools of ripe cod gather in winter and spring, as Earll (1880) described long ago, is probably the most important center of production in the inner part of the Gulf of Maine north of Cape Ann, but this, like the Massachusetts Bay spawning ground, is limited to a rather small and well defined area of bottom extending only from a few miles south of the Isles of Shoals to abreast of the mouth of the Merrimac River and (less productively) to Cape Ann, chiefly within 4 to 6 miles of land.

Spawning cod are seen only in comparatively small numbers and at scattered localities in the coastal zone north and east of the Isles of Shoals, the most productive of these minor spawning grounds being near Cape Elizabeth, off Casco Bay, off the Sheepscott River, off Boothbay, and in the neighborhood of Mount Desert Island. Very few ripe cod are reported along the Maine coast farther east, and although cod eggs have been taken in the Bay of Fundy the larvæ are unknown there. The egg-collecting campaigns of the several hatcheries have been so extensive and have been prosecuted over so many years that we can confidently assert that there are no centers of production anywhere within the Gulf east of Cape Elizabeth comparable to the Georges Bank, Nantucket Shoals, Ipswich Bay, or Massachusetts Bay spawning grounds. It may prove that the west coast of Nova Scotia is equally prolific, but no definite evidence that cod breed there in any abundance has yet been obtained. We should also point out that the small ledges in the western part of the Gulf—e. g., Jeffreys and Platts—are not breeding centers though they are important feeding grounds. We can not speak for Grand Manan Bank or German Bank. Thus cod are quite as local in their choice of spawning grounds in the Gulf of Maine as they are in Norwegian waters.[94]

A glance at the chart (fig. 212) will show how limited the more important breeding grounds of the southwestern part of the Gulf of Maine are in extent (not more than 300 square miles in all) compared to the whole peripheral zone of this part of the Gulf within the 50-fathom curve, and so definitely limited are they that ripe fish are seldom found even close by, though the fishing for green or spent fish may be good there. For instance very few spawning cod are ever taken either on Jeffreys Ledge off Cape Ann, or on Stellwagen Bank at the mouth of Massachusetts Bay, though both these shoals yield good fares of fish at times. As a consequence of the limited area of the Gulf of Maine spawning grounds cod congregated on them in such numbers during the spring of 1879—when fishing was less intensive than at present and perhaps the schools correspondingly more plentiful—that more than 11,000,000 pounds of cod, mostly spawning fish, were taken on the Ipswich Bay ground alone by local fishermen.

Cod evidently spawn as far south and west as New Jersey, for a portion of the fish caught off Atlantic City in late autumn and early winter are described by local fishermen as ripe,[95] but no information is available as to precise spawning grounds

[94] See Hjort (Rapports et Procès-Verbaux, Conséil Permanent International pour l'Exploration de la mer, Vol. XX, 1914).
[95] Smith, 1902, p. 208.

or seasons west of Nantucket. On the other hand, cod eggs are produced in profusion as far north as the Gulf of St. Lawrence and the Grand Banks, but it is not known how much spawning takes place along the eastern coast of Labrador.

Cod spawn in shoaler water than haddock. In fact, we can find no record of ripe fish deeper than 50 fathoms, and most of the Gulf of Maine spawning takes place on much shoaler bottoms. The Georges Bank ground, for example, is about 25 to 35 fathoms deep; the Nantucket grounds are hardly anywhere deeper than 20 fathoms and as shoal as 7 fathoms in places; the Massachusetts Bay grounds are about 12 to 25 fathoms; and the Ipswich Bay ground only 5 to 25 fathoms according to the precise locality. In short, very few, if any, cod spawn deeper than 30 fathoms in the Gulf, and on the inshore grounds the major production of eggs takes place in water shoaler than 15 fathoms. We wish to emphasize the fact that no cod breed anywhere in the central deeps of the Gulf outside the 50-fathom contour.

With the breeding grounds of the cod so localized and spawning taking place close to bottom, and with the chief production of eggs during the cold months, the physical state of the water in which eggs are produced can be stated with some confidence at any particular locality and date, but corresponding to the prolonged period of reproduction spawning takes place over rather a wide range both of temperature and of salinity. On the Ipswich Bay grounds, for example, ripe fish are taken when the bottom water is still as warm as 44° to 46° (early September), but they appear in greater numbers in temperatures of 41° to 43° (January); and as the breeding season progresses the temperature falls, spawning being at its height in the minimum temperatures of the year (March)—that is, 33° to 37.5°—though the fish continue to spawn until the bottom water has once more warmed to 38° to 41° (mid-May).

On the Massachusetts Bay ground the peak of the spawning season is reached and passed before the temperature drops to its winter minimum, hence in decidedly warmer water than in Ipswich Bay, spawning fish appearing in numbers (late November) while the bottom water is still as warm as 44° to 47°, with the chief production taking place in temperatures of 36° to 42° (December, through January). Most of the spawning takes place in the falling temperature on this ground, although some cod breed there right through the coldest season (minimum temperature 33° to 37°). The temperature range through which the cod breed on the offshore grounds can not be stated so precisely, for want of autumn and early winter data.

Cod kept in captivity at Woods Hole spawn freely through an equally wide range of temperature, eggs even being produced (and quite normally, to judge from the successful incubation of the resultant eggs in the warmer water of the hatchery) in February when the pool may have cooled to 30°, an interesting fact, for if left at liberty the fish in question would have spawned naturally in water at least as warm as 36° to 38°. Cod spawn in water as cold as 32° in the Gulf of St. Lawrence and probably also on the Newfoundland Banks.[96]

[96] Hjort. Canadian Fisheries Expedition, 1914–15 (1919), p. xxvii.

It is interesting to note that on the whole cod spawn in rather colder water in the Gulf of Maine (still more so in the Gulf of St. Lawrence and on the Newfoundland Banks) than on the other side of the North Atlantic or about Iceland, where the chief production of eggs takes place at temperatures of 40° to 45°.

The salinities in which cod spawn in the coastwise waters of the Gulf of Maine depend on the precise locality, depth, and season. Probably none spawn in water fresher than 32 per mille [97] nor salter than 32.8 per mille, either on the Ipswich Bay grounds or on the Massachusetts Bay grounds, and as far as our records go they point to a salinity of about 32.6 per mille as typical for the spawning of the cod on Georges Bank. This is water much less saline than ripe cod seek in European seas,[98] and necessarily so, the Gulf of Maine being decidedly fresher at all times (p. 443) than the Norwegian Sea or than the waters around Iceland.

On the Massachusetts Bay spawning ground the density of the water is high enough to insure the flotation of the eggs throughout the breeding season, but in Ipswich Bay the spring freshets often so freshen the surface that late-spawned cod

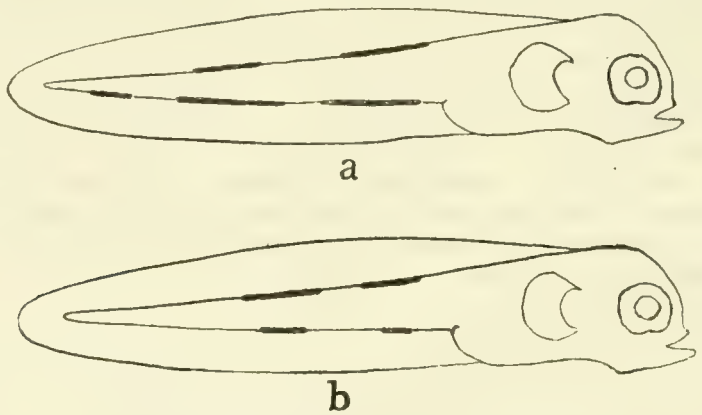

FIG. 213.—Diagram of the pigmentation of the youngest larvæ of cod (a) and American pollock (b). After Schmidt

and haddock eggs may fail to rise to the uppermost water layers, a phenomenon which hinders the operations of the hatchery but which does not militate against the successful incubation of the eggs in nature, since they would merely float suspended at some deeper level. This subject is discussed at greater length in connection with the haddock (p. 443).

The cod is one of the most prolific of fishes, so much so that a female 39 or 40 inches long may be expected to produce about 3,000,000 eggs and one of 41 inches at least 4,000,000. Earll estimated the number in a 52½-inch fish weighing 51 pounds at 8,989,094, with 9,100,000 in a 75-pounder.

The eggs are buoyant, transparent, without oil globule, and 1.16 to 1.82 mm. in diameter. Gulf of Maine eggs, artificially fertilized and measured by Welsh, averaged about 1.46 mm. in diameter.

[97] The surface may be much fresher in spring, but not the bottom water in which the fish are lying.
[98] 34.5 to 35 per mille, according to Damas.

The period of incubation for cod eggs depends on temperature. According to experience at the hatcheries hatching may be expected in 10 or 11 days at 47°, in 14 or 15 days at 43°, in 20 to 23 days at 38° to 39°, and not for 40 days or more if the water is as cold as 32°. Fertilization can take place and development commence in temperatures even lower than this, as proved by experiments by Krogh and Johansen,[99] but their observation that the mortality is great among eggs incubated at 32° (although full development can take place) corroborates the experience of the hatcheries, where it has proved impossible to hatch more than 25 to 50 per cent of the eggs in water as cold as this, while the relative strength of the larvæ hatched at different temperatures points to 41° to 47° as most favorable for incubation. All this suggests that extreme cold prevents the successful reproduction of the cod, not by interfering with spawning (for this can take place in the lowest temperatures found anywhere in the open sea) but by its effect on the developing eggs.

Newly spawned cod eggs are indistinguishable from those of the haddock, with which they intergrade in size, but by the time the embryo is as long as the circumference of the egg (that is, shortly before hatching) the pigment of the cod gathers in 4 or 5 distinct patches—one over the region of the pectoral fin, one above the vent, and the others equally spaced behind it (fig. 205)—whereas in the haddock the pigment cells are arranged in a row along the ventral side of the trunk (p. 444). There is also danger of confusing newly spawned cod eggs with those of the witch flounder (p. 515), which they overlap in size; but the black pigment of the cod eggs identifies them as gadoid as soon as it appears, the embryonic pigment of the witch being yellow. (See also under the haddock on p. 443.)

At hatching the larvæ are about 4 mm. long with the vent (which is close behind the yolk sac) located at the base of the ventral fin fold on one side instead of at its margin, so that the intestine apparently ends blindly as is the case with haddock and pollock larvæ, also. At this stage young cod much resemble the latter but are easily separable from them by the fact that the pigment is in two dorsal and three (rarely two) ventral bars, with the dorsal bars shorter than the ventral bars opposite them, whereas in pollock larvæ up to 10 mm. long the dorsal bars are longer than the opposite ventral bars (p. 405). Neither is there any danger of confusing cod larvæ with haddock even at this early stage, for the latter are not barred but have a continuous row of pigment cells along the ventral margin of the trunk behind the vent besides other patches on the nape and in the lining of the abdomen (p. 444).

When first hatched the young cod float helplessly, yolk uppermost, but they assume the normal position in about 2 days, the yolk being absorbed and the mouth formed in 6 to 12 days, according to temperature, when the larvæ are about 4.5 mm. long. As the little cod grows the pigment bars gradually fuse, and at 8 to 10 mm. a median band forms, but cod 10 to 20 mm. long may easily be distinguished from pollock by the fact that the pigment extends to the tail, whereas in the latter it

[99] Dannevig. Canadian Fisheries Expedition, 1914–15 (1919), p. 44.

ends abruptly some distance in front of the tail. Haddock of this size show much less pigment (p. 444). Cod fry of 15 to 30 mm. may be recognized by the location of the vent under the second dorsal fin, combined with dense pigmentation. The dorsal and anal fin rays begin to appear at a length of 10 to 13 mm.; at 20 mm. they have attained their final number and the separate fins are outlined; while at 30 mm. the fry begin to show the spotted color pattern so characteristic of the cod.

FIG. 214.—Localities where cod (●) and haddock (▲) larvæ have been taken in the tow nets

An important question for future solution is: What proportion of the cod larvæ hatched on the Gulf of Maine spawning grounds survive? We have no data whatever to offer on this, nor do we think it wise to draw any conclusions from the fact that we have taken few cod larvæ in our tow nets (only 80 or 90 all told), because this may have been purely accidental, due to the fact that we have made few hauls in Ipswich Bay or the southern part of Massachusetts Bay and none on the offshore spawning grounds at the critical season.

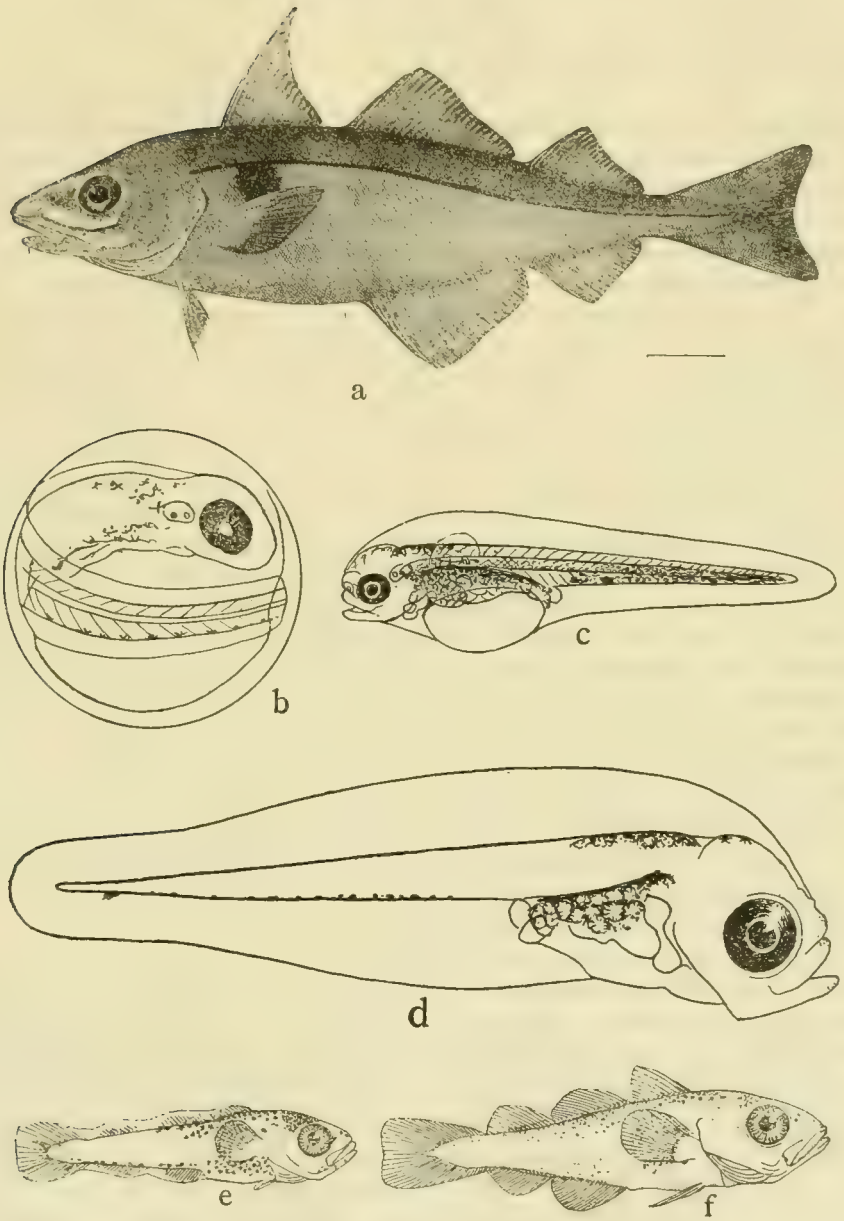

FIG. 215.—Haddock (*Melanogrammus æglifinus*)

a, Adult. *b*, Egg (European). After Heincke and Ehrenbaum. *c*, Larva (European), just hatched. After Heincke and Ehrenbaum. *d*, Larva (European), after yolk is absorbed, 4.2 millimeters. After Ehrenbaum. *e*, Larva (European), 15 millimeters. After Schmidt. *f*, Fry (European), 25 millimeters. After Schmidt

153. **Haddock** (*Melanogrammus æglifinus* Linnæus)

White-eye

Jordan and Evermann, 1896–1900, p. 2542.

Description.—The most obvious characters in which the haddock differs from the cod are its black lateral line (that of cod and pollock is paler than the general ground tint) and the presence of a dusky blotch on the side over the middle of the pectoral fin and close below the lateral line. Furthermore its first dorsal fin is relatively higher than that of a cod and considerably higher than either the second or third dorsal, more acutely triangular in outline, and with slightly concave margin. The margin of the haddock's tail is more concave or "lunate" than that of the cod, the second and third dorsals and both anals are more angular than is usually the case with cod, though similarly rhomboid in outline, and the two anals differ more in size in a haddock than in a cod. The haddock's mouth is relatively the smaller, not gaping back to below the eye, and the lower profile of the face is straight and the upper only slightly rounded, giving the nose a characteristic wedge-shaped outline in side view. The upper jaw projects further beyond the lower in the haddock than in the cod, and the snout is usually more pointed and the body more compressed, but the general arrangement of the fins is the same and there are about the same number of dorsal fin rays in haddock as in cod (14 to 17, 20 to 24, and 19 to 22, in the first, second, and third fins, respectively). While the anals average one or two more rays in each fin (21 to 25 and 20 to 24), individual cod may have more anal rays than individual haddock. Finally, the haddock is a slimmer fish than the cod and its scales (which clothe it from nose to tail) are smaller—indeed hardly visible through the mucus with which the skin is coated.

Color.—A live haddock is very different from the pale dirty gray object to be seen in the market. When fresh from the water the top of the head and the back down to the lateral line are dark purplish gray, paling below the latter to a beautiful silvery gray with pinkish reflections, with the black lateral line and the sooty shoulder patch just mentioned standing out vividly. This patch—the "devil's mark"—is indefinitely outlined and varies in size and in distinctness, but we have never seen a haddock (nor heard of one) lacking it. The belly and lower sides of the head are opaque white. The dorsal, pectoral, and caudal fins are dark gray; the anals pale like the lower sides and black specked at the base; the ventrals white more or less dotted with black. Haddock usually run very uniform in color, but occasionally one shows from one to four dark transverse bars or splotches in addition to the black shoulder blotch. Several of these serially striped haddock have been taken in Passamaquoddy Bay,[1] and we have seen such near Mount Desert.

Size.—The haddock is a smaller fish than the cod, the largest on record being 37 inches long and weighing 24½ pounds.[2] The largest among 1,300 fish measured and weighed by Welsh near Gloucester during the spring of 1913 measured 35½ inches in length and weighed about 16½ pounds. Very few, however, were as

[1] Prince, 1917, p. 86.

[2] Day. The fishes of Great Britain and Ireland, 1880–1884. London.

long as 34 inches, the great majority running from 23 to 30 inches and from 5 to 10 pounds, while fish of 24 to 28 inches and weighing 5½ to 8¼ pounds formed almost three-fourths of the total. The relationship between length and weight in 780 ripe fish (460 males and 320 females) measured by Welsh is illustrated on the accompanying diagram (fig. 216).

General range.—Both sides of the North Atlantic; most abundant on the American coast from Cabot Strait to Cape Cod. In winter haddock are taken southward to New York and New Jersey, and they have been recorded in deep water as far as the latitude of Cape Hatteras; but the species as a whole is so much more closely confined to waters east of Marthas Vineyard than is the cod that only 85,791 pounds of

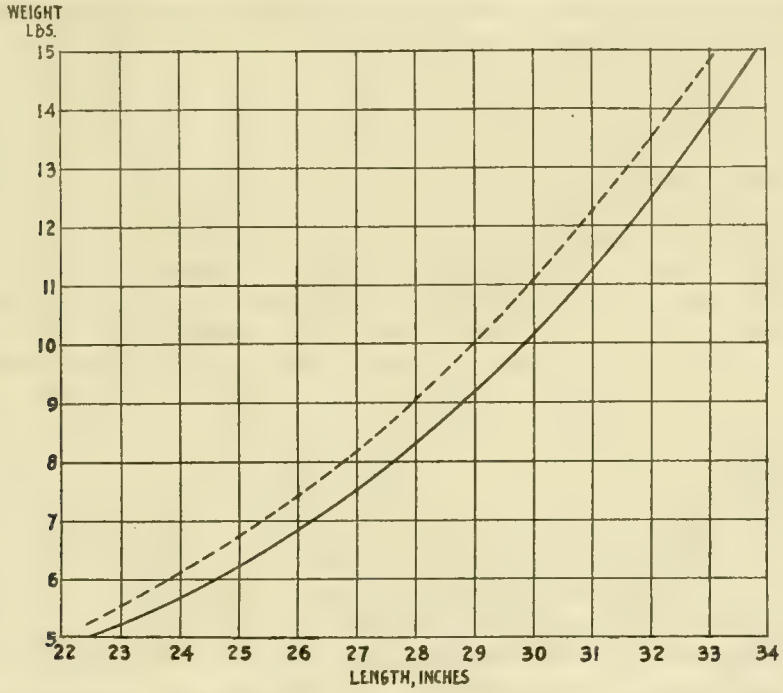

FIG. 216.—Average weight of ripe haddock of different lengths, male (——) and female (. . . .), at Gloucester, March to May, 1913

haddock were caught off New York and New Jersey in 1915, contrasting with an annual catch of one to two million pounds of cod for that part of the coast. Nor does the range of the haddock extend as far north as that of the cod, only a few being taken in the southern part of the Gulf of St. Lawrence or in the Atlantic northward of the Grand Banks, and none at all beyond the Straits of Belle Isle, whereas multitudes of cod summer along the east coast of Labrador.

Occurrence in the Gulf of Maine.—Haddock, cod, pollock, mackerel, and herring together are the backbone of the great commercial fisheries of the Gulf of Maine. In weight of fish caught haddock are surpassed only by herring (the latter are incomparably the most numerous fish in the Gulf, as pointed out on page 93); and by cod (p. 412) alone in the value of the catch.

Haddock are very plentiful all around the Gulf (including the Bay of Fundy) as well as on all the offshore banks, especially on Georges where they greatly outnumber the cod. In spite of their preference for deeper water (p. 435) a larger number of individual haddock than of cod are taken over the coastal belt generally, within 20 to 25 miles of land, though the latter are so much larger individually that the catch of cod is the greater by weight. In 1919, for example, the catch on the inshore grounds (including that of both small boats and vessels) was about 20,000,000 pounds of cod (p. 412), as compared with 15,000,000 pounds of haddock. The landings along several stretches of the coast for that year will further illustrate the universal abundance of haddock. Thus between 5,000,000 and 6,000,000 pounds were taken off western Nova Scotia and on the south side of the mouth of the Bay of Fundy (including German Bank fish); about 750,000 farther in on the Scotian side of the bay and about 400,000 on the New Brunswick side; about 700,000 pounds thence to Penobscot Bay; and about 500,000 between Penobscot and Casco Bays. The inshore grounds from Cape Elizabeth to Cape Cod (including Stellwagen Bank but not Jeffreys Ledge) yielded nearly 5,000,000 pounds, besides some 2,000,000 more taken by large vessels on the inshore grounds but which we can not classify by localities. Small isolated rocky banks, such as Cashes and Platts, support few haddock compared to the considerable stock of cod (p. 412), but they are extremely abundant on the offshore grounds generally, swarming in the South Channel in particular. In fact, this ground supplies fully half the haddock brought into Boston. They are so plentiful at one time or another over the whole length of Georges Bank that it is a common occurrence for an otter trawler to catch 10,000 to 20,000 fish, large and small, in 5 to 6 days' fishing, and not unheard of for one to take 50,000. In number (not in weight) haddock of all sizes made up 60 to 70 per cent of all the fish caught there by certain otter trawlers in the year 1913, while cod amounted to less than 10 per cent. By weight, however, the landings of cod from Georges Bank may be larger than those of haddock, both because cod average so much larger individually and because more of the immature haddock than immature cod are caught and thrown back. The following figures give the landings of haddock, in pounds, at Boston and Gloucester, Mass., and Portland, Me., from certain offshore grounds in 1919:

	Pounds
South Channel	34, 929, 521
Georges Bank	17, 620, 977
Browns Bank	4, 355, 637
Jeffreys Ledge	1, 093, 986
Off Chatham	1, 372, 625
Stellwagen Bank	736, 328
Platts Bank	68, 101
Fippenies Bank	34, 435

Haddock are also plentiful on Browns Bank; perhaps less so on German Bank, though considerable numbers are caught there and on the broken grounds off Lurcher Shoal; and they are less plentiful than other ground fish on Grand Manan Bank. In 1919 (a representative year) the total catch of haddock in the Gulf of Maine, inshore and offshore, was at least 85,000,000 pounds, representing more

than 15,000,000 fish, which considerably surpassed the catch of cod in weight and far more in number of individual fish.

No evidence whatever has yet been gathered as to the relation which the annual catch of haddock bears to the total stock of fish in the Gulf, but judging from European experience in the recapture of tagged cod we hazard the guess that at this moment it supports not less than 150,000,000 haddock of marketable size and many times this number of smaller fish.

Habits.—Probably the lower limit of depth is about the same for the haddock as for the cod in the Gulf of Maine (p. 413), few being caught much below 100 fathoms,[3] but on the average haddock live deeper than cod, very few being caught in less than 5 to 10 fathoms and most of them in 25 to 60 fathoms. Haddock, large or small, so seldom come into the very shoal waters along rocky shores and over ledges where young cod are plentiful that the pound nets of Massachusetts reported only about 5,000 pounds of haddock in 1919, as compared with almost 300,000 pounds of cod. Neither do we remember hearing of a haddock of any size in any of the shoal harbors where little pollock so abound, a difference in habitat between these closely related species holding from the time when the young fry first seek bottom, for haddock usually do so in 20 to 50 fathoms or deeper, very rarely close to the shore, and perhaps never in the littoral zone.[4]

Haddock are even more distinctively ground fish than cod, and though, like the latter, they pursue herring and other small fish, they so rarely rise far from the bottom that we have never heard of a school coming to the surface or driving their prey ashore on the beach, events by no means unusual with cod and a characteristic phase in the life of the American pollock (p. 400).

Haddock are less catholic than are cod in their choice of the type of bottom, being hardly ever caught over ledges, rocks, kelp, etc., on the one hand, where cod are so plentiful, or, on the other, on the soft oozy mud to which hake resort, but chiefly on broken ground, gravel, pebbles, clay, smooth hard sand, sticky sand of gritty consistency, or where there are broken shells. They are especially partial to the smooth areas between rocky patches. Haddock, unlike cod, never run up estuaries into brackish water—much less into fresh water—but are typically offshore fish, though they enter the bays and reaches between the islands along the coast of Maine in some numbers (p. 439).

Haddock, like cod, diminish in numbers from the mouth toward the head of the Bay of Fundy, and Canadian fishery statistics show that they are far more plentiful on its Scotian shore than on its New Brunswick shore.

Food.—During the first few months, while haddock fry are living pelagic near the surface, they probably depend on copepods as cod do, but so far as we are aware no stomach contents of haddock as young as this have been examined. After they take to the bottom they become bottom feeders like cod, devouring all kinds of invertebrates so indiscriminately that, as Baird (1889, p. 37) long ago remarked, "a complete list of the animals devoured by the haddock would doubtless include

[3] Goode and Bean (1896) list a haddock from 499 fathoms but with suspicion as to the accuracy of its label.

[4] In this respect the fact that haddock fry less than 1 year old have never been reported in shoal water in the Gulf or at Woods Hole corroborates European fishing experiments summarized by Damas (Rapports et Procès-Verbaux, Conséil International pour l'Exploration de la Mer, Vol. X, 1909) and by Schmidt (*Ibid.*).

nearly all the species belonging to the fauna" of the particular ground on which the fish in question were living. The larger Crustacea, such as hermit, spider, and common crabs, shrimps, prawns, and amphipods, with gastropods and bivalve mollusks in great variety, worms, starfish, sea urchins, sand dollars, brittle stars, and sea cucumbers, all enter regularly into the dietary of the haddock, with probably the commoner mollusks, crabs, small sea urchins, and brittle stars their chief subsistence, according to locality. It has often been remarked (this Mr. Clapp corroborates) that they must root out much of their food from the mud and sand of the sea bottom, for they depend largely on burrowing bivalves and worms, which they could obtain in no other way—for example, haddock caught near Eastport contained eight varieties of annelids. They are also said to congregate about clam beds. On the other hand none of the Eastport fish opened by Doctor Kendall (1898) had risen to take the large pelagic shrimps (euphausiids) so abundant there and which are the chief food of the local pollock, this being an illustration of how close haddock hold to the bottom.

Mr. Clapp listed no less than 68 species of mollusks, both bivalves and gastropods, from 1,500 haddock caught on the northwest part of Georges Bank in 40 to 60 fathoms, and he has called our attention to the fact that haddock usually contain smaller shells than do cod, and never the very large sea clams (Mactra) which are so important a constituent of the diet of the latter. Furthermore, haddock eat more worms than cod, and they are often packed full of worm tubes when caught on bottoms covered with the latter—the "spaghetti bottom" of fishermen—such, for example, as the locality known as "Cove Clark" on the northwest face of Georges Bank (about lat. 41° 8′ by long. 68° 40′). Haddock, like many other fish, take squid when opportunity offers, and they are usually described as fish eaters like cod. In Norwegian waters they are said to prey on schools of herring. Haddock caught at Woods Hole have been seen full of them, and most American writers credit their diet with herring, cunners, etc. We can only state in regard to this that none of the shore fish examined by Welsh near Cape Ann in 1913, nor the Georges Bank fish opened by Mr. Clapp (5,000 altogether), contained a fragment of fish of any kind, nor have any of the fishermen of whom we have inquired (and their practical experience is of course vastly wider than ours) described haddock as feeding to any great extent on fish. Thus it is evident that while Gulf of Maine haddock prey on small herring at times, fish is certainly an insignificant part of their diet. Haddock have also been accused of feeding greedily on herring spawn—perhaps without much justice.

Judging from Welsh's experience with the fish breeding near Cape Ann during April, 1913, haddock fast even more rigorously than cod at spawning time, because more than 95 per cent of the hundreds of fish caught in the gill nets were totally empty, and because line trawls set near by were bringing in very few haddock but were taking hake in fair numbers. In fact it was not until the introduction of the gill-net and otter-trawl fisheries that any considerable toll was taken of the haddock while spawning.

Rate of growth.—The haddock shows its age on its scales almost as clearly as does the herring. Miss Duff (1916, p. 95) gives the following lengths for Bay of

Fundy haddock of different ages, estimated from scale studies combined with measurements of the different length groups represented among 460 specimens. European measurements are added for comparison.

Bay of Fundy fish		North Sea fish [1]		Norwegian fish [1]	
Age	Length	Age	Length	Age	Length
Years	*Inches*	*Years*	*Inches*	*Years*	*Inches*
1¼	5.1	1½	10	1¾	10
2¼	12.3	2½	11	2¾	12
3¼	15.5	3½	13	3¾	15
4¼	17.9	4½	16.5	4¾	19
5¼	21	5½	18.5	5¾	19
6¼	21.7	6½	21	6¾	21
7¼	22.8	7½	23	7¾	23
8¼	23.8	8½	26	8¾	24
				9¾	26

[1] Damas (Rapports Procès-Verbaux, Conseil Permanent International pour l'Exploration de la mer, Vol. X, 1909) has tabulated the measurements and ages of large numbers of haddock from various North European localities.

It appears from these data that Bay of Fundy, North Sea, and Norwegian haddock all grow rapidly and at about the same rate until they are 5 or 6 years old, but that the European haddock outstrips the American fish thereafter, though all continue to grow in length to a considerable age. The oldest haddock recorded by Damas were two of 12½ years, judged by their scales, and, respectively, 30.4 and 31.1 inches long. This, with the fact that his largest specimen was a 10½-year-old of 32.2 inches, suggests that the largest Gulf of Maine fish are 12 to 15 years old. The lengths given in the preceding table are averages, and there is so much individual variation that a fish of a given age may be smaller than one a couple of years younger or larger than one 2 or 3 years older, probably due to the food supply. For example, North Sea fish of 2 years varied from 7.6 to 15.6 inches in length; 3-year fish from 10.4 to 16.4 inches; 4-year-olds from 12.8 to 21.2 inches; 5-year fish from 14.4 to 24 inches; 6-year fish from 16 to 27 inches; and those 7 years old from 17.6 to 28 inches. Most of the haddock of the younger year classes are grouped near the average sizes for their age, fish of 6 years and older being more evenly distributed among different sizes.

Age at maturity.—The smallest sexually active specimens found by Welsh among 1,300 haddock were two females of about 20 inches each (that is, 4 or 5 years old), which supports Miss Duff's argument that the slackening of the rate of growth at 4 or 5 years, which she observed, reflects the first ripening of the sexual organs.

Migrations.—Broadly speaking, the haddock is a year-round resident in the Gulf of Maine, where its only extensive and regular migrations after its fry are large enough to seek bottom are in the form of annual concentrations on and dispersals from its spawning grounds. During its first few months of life (p. 438), however, while it is floating near the surface and drifting with the current, it undoubtedly carries out involuntary journeys which may be of considerable extent. Unfortunately we have very few records for these larval haddock—probably because we have made very few tow-net hauls at appropriate localities and at the critical season, that is, late May and June. They are suggestive as far as they go, however, for they are concentrated in its southwest part, on Georges Bank and Nantucket

Shoals, leaving the coastal zone east of Cape Elizabeth and the whole deep basin as barren of larval haddock (so far as our catches go) as it is of young cod, young silver hake, young flatfish, and, in fact, of most other larval fishes except rosefish (p. 309) and herring. This, with other lines of evidence, points to a drift around the periphery of the Gulf from northeast to southwest, a subject to be discussed elsewhere.

It has long been known that the young fry of the haddock, like those of other gadoids, often live commensal with the larger jellyfishes in European waters, and Welsh's discovery of many small haddock of 30 to 77 mm. in company with the common red jellyfish (Cyanea) on Georges Bank and off Nantucket Island, July 23 and 25, 1916, with Willey and Huntsman's (1921, p. 2) notice of young haddock about 2 inches long under Cyanea in the Bay of Fundy, proves that they follow the same habit in the Gulf of Maine. In fact it is in company with Cyanea that young haddock in the late larval stage have most frequently been taken in the eastern Atlantic, and the question whether this commensalism between young fish and Medusa is as general off the American coast is worth attention, because it is while drifting with these nurses that young gadoids carry out their longest journeys.

It is fair to assume that young haddock live pelagic for about as long in American as in European waters—that is, for a period of three months or so (we have no first-hand information)—before they seek the bottom. Nothing is known about them in the Gulf of Maine from that time until they begin to be caught by the otter trawlers as yearlings—6 inches to a foot long. These little fish—too small for market—are so plentiful on Georges Bank and in the South Channel (where they form 35 to 40 per cent or more of the total catch of haddock in point of numbers and more than one-fifth of the fish of all kinds) that hosts of haddock fry must settle to bottom on these offshore banks generally. Probably these young haddock are likewise plentiful on the inshore grounds, for yearlings are reported by Huntsman in the Bay of Fundy, but they are seldom seen there, being too small to be caught on line trawls or in gill nets.

Adult haddock roam from place to place in search of food like cod, and so constantly that where there is good fishing to-day there may be none to-morrow. However, these movements seem mostly of short extent, from place to place on a given bank as food is locally exhausted or for some other cause. How much interchange of haddock there may be from bank to bank or between inshore and offshore grounds is unknown, but the fish that inhabit the coastwise belt carry out a local and irregular migration inshore in winter and early spring and offshore again in June or July. Certain bodies of fish may linger all summer in the deeper channels among the islands of Maine, on patches of suitable bottom. In 1923, for instance, haddock were caught throughout July, August, and September between Suttons and Bear Islands, near Mount Desert Island, as well as at other inshore localities near by. The general opinion is that this fish is not such a wanderer as the cod, and there is no positive evidence—such as finding fish with foreign hooks in them—that any haddock visit the Gulf of Maine from far distant grounds (that is, from the Scotian or Newfoundland Banks), or that any considerable immigration takes place into the Gulf around Cape Sable.

Haddock are to be caught in the Gulf of Maine all the year round, and the landings from the offshore grounds in general do not fluctuate more widely from month to month than one would expect from bad weather, ill luck, market conditions, etc.; but the catch inshore is greatest in spring, being augmented by the gathering of the fish for spawning. The following are the landings of fresh haddock at Boston and Gloucester, by months, for 1919, representing four-fifths of the total catch for the Gulf:

Month	Pounds	Month	Pounds
January	6, 713, 778	July	6, 088, 984
February	7, 078, 314	August	6, 307, 368
March	5, 561, 370	September	5, 632, 384
April	3, 418, 718	October	6, 176, 150
May	4, 701, 026	November	4, 187, 835
June	5, 289, 054	December	4, 277, 640

Breeding.—The rather level bottom on the eastern part of Georges Bank (fig. 217) is the most productive spawning ground for the haddock off the North American coast—one of the most productive anywhere for that matter. Our experience on the *Albatross* in 1920, when we found haddock eggs in great abundance (p. 442) in March and April (captures of ripe fish, male and female, in the trawl established their identity as haddock, not cod) showed that the spawning fish are to be expected anywhere in that general region over an area of at least 1,600 square miles. It is not known whether haddock breed as plentifully on the deeper parts of the bank to the west, but some gadoids (haddock, cod, or both) were spawning on the western end late in February in 1920, proven by the presence of a few cod or haddock eggs there. Browns Bank is likewise a productive nursery for haddock, for a fair proportion of the many gadoid eggs towed there by the *Albatross* in April, 1920, were far enough advanced in development to show their identity as such.

Although the inshore spawning grounds of the Gulf of Maine haddock are the annual goal of great numbers of breeding fish, they are neither so sharply circumscribed nor so regularly repaired to as those of the cod. Our own egg records, together with reports from the hatcheries and from local fishermen, are enough to prove that haddock spawn here and there all along the coastal belt from Cape Cod to the entrance to the Bay of Fundy, the most important breeding grounds within this zone being along the outer (eastern) and northern slopes of Stellwagen Bank, whence many eggs are obtained for the Gloucester hatchery, and in the coastal belt between Cape Ann and Cape Elizabeth, especially off Ipswich Bay, near the Isles of Shoals, about Boon Island, and off Wood Island. It was on the Isles of Shoals-Wood Island grounds that Welsh carried on his studies on the haddock during the spring of 1913 (p. 432). Ripe haddock are caught on the shelving sandy bottom along Cape Cod as far south as Nauset, and gill-netters sometimes get good fares of ripe fish off Boston Harbor, but no great body spawns in the inner parts of Massachusetts Bay, and few if any on the cod-spawning grounds off Plymouth (p. 425). Breeding haddock are plentiful east of Cape Elizabeth in some years and scarce or altogether absent in other seasons or over terms of years. For example, Captain Hahn, superintendent of the Boothbay hatchery, writes that in April and May of 1912 spawning haddock in abundance came into Boothbay Harbor and into Line-

kin Bay, while gill-netters made large catches in Muscongus Sound and the outer part of Penobscot Bay toward the end of the period, but that spawning haddock have never since approached this part of the coast in numbers sufficient to support any extensive fishery or to provide the hatchery with more than a few eggs.

Spawning haddock have also been reported to us from the neighborhood of Mount Desert Island and off Cutler, while we found a few cod-haddock eggs near

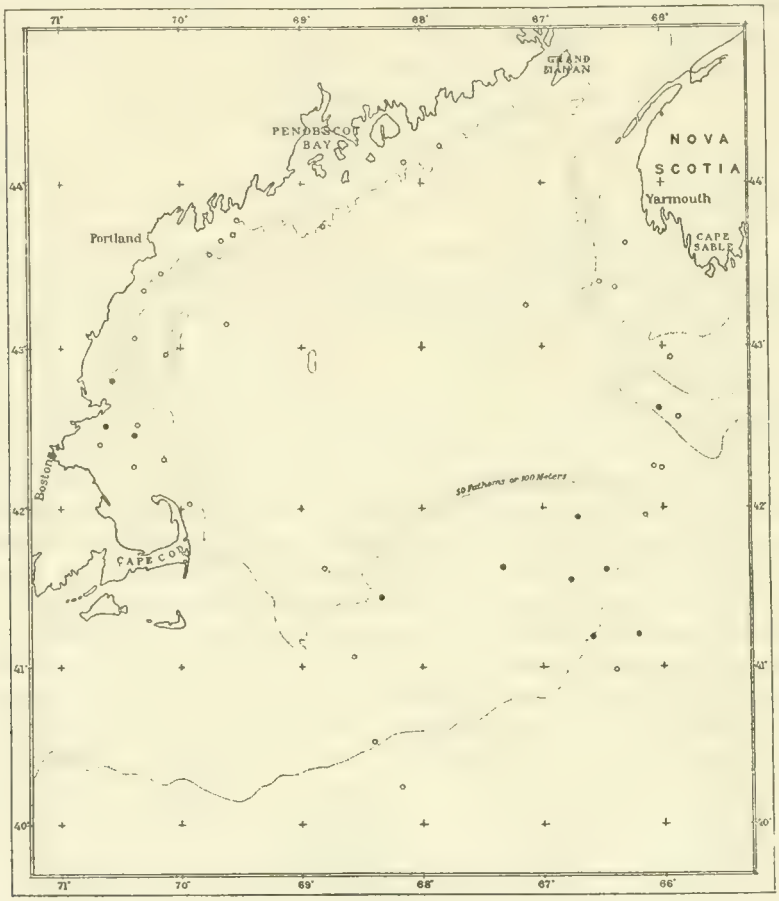

FIG. 217.—Localities where haddock or cod-haddock eggs were taken from February to June during the years 1913, 1915, and 1920. ○, less than 100; ●, more than 100 per station

Petit Manan Island on April 12, 1920,[5] but there is no reason to suppose that any considerable body of haddock ever breed along the Maine coast east of Mount Desert, nor on the northern side of the Bay of Fundy, where neither eggs, larvæ, nor young fry have ever been seen. However, our capture of a few haddock eggs [6] and others in the younger "cod-haddock" stage (p. 443) in Petit Passage on June

[5] In a previous report (Bulletin, Museum of Comparative Zoology at Harvard College, Vol. LXI, 1917, p. 258) I recorded eggs taken along this part of the coast in June as "cod-haddock," but fresh examination of the material shows that they might equally have belonged to the witch flounder (p. 515), none being sufficiently advanced in incubation to show the pigment.

[6] Far enough advanced to show the pigment in its distinctive arrangement.

10, 1915, proves that some spawn on the Nova Scotian side of the bay near its entrance, and according to general report a few do so on the coastal banks along the western shores of Nova Scotia southward to Cape Sable,while we have taken a few cod or haddock eggs on German Bank in our tow nets in May. We can offer no evidence as to whether Platts Bank serves as a breeding ground, for no pigment had yet appeared in the few eggs taken there April 10, 1920, hence they might as well have been cod as haddock.

Our own observations, added to the experience of the spawn takers of the bureau and of local fishermen generally, convince us that haddock, like cod, seek definite breeding grounds, and do not spawn anywhere and everywhere within the depth zone and over the types of bottom which they inhabit, as might be expected to be the case in a region where the depths are as irregular, the bottom as broken and various in texture, and the salinity and temperature varying as widely from place to place as in the Gulf of Maine. Where the slopes are gradual, the bottom smooth, and the physical state of the water constant over large areas, as they are over most of the North Sea, it may be as hopeless to delimit definite breeding grounds for haddock, cod, or other fishes as some European students have believed.

Depth of spawning.—The important spawning grounds for haddock in the Gulf of Maine are all shoaler than 75 fathoms, but haddock commonly breed in deeper water than cod, and the presence of great numbers of newly spawned eggs floating on the surface out to the 100-fathom contour on the southeastern slope of Georges Bank at the height of the breeding season (March 20) of 1920 is sufficient evidence that the fish were spawning down to that depth. Similarly, we towed cod or haddock eggs (probably haddock, judging from the season) over the 100-fathom contour off the slope of German Bank on May 6, 1914; but this case is not as clear, for there was a decided set of surface water from the eastward at the time which may have brought the eggs from the shoaler part of the bank. One hundred fathoms may be set as the lower limit to any considerable production of eggs in the Gulf of Maine, and no haddock spawn in the deep basin, the few eggs found there (e. g., in the southeast deep and in the Eastern Channel, April, 1920), being flotsam from the neighboring slopes or banks. On the other hand haddock may occasionally deposit their eggs within a couple of fathoms of the surface—for instance, in Boothbay Harbor on the occasion just noted (p. 439)—but this is most unusual, 15 to 20 fathoms being the upper limit to regular spawning. The depths of the more productive spawning grounds, individually, are as follows: Browns Bank, 30 to 50 fathoms and probably deeper; Georges Bank from about 30 down to 100 fathoms, as just noted; Cape Cod ground, about 40 to 70 fathoms; and from 20 to 70 fathoms on the more productive Stellwagen ground. Between Cape Ann and Cape Elizabeth haddock spawn in 20 to 65 fathoms. On the whole haddock spawn rather shoaler in the Gulf of Maine than in the North Sea region, where the maximum production of eggs takes place at 50 to 100 fathoms. Consequently there is less difference in this respect between haddock and cod in the western than in the eastern North Atlantic. Neither do haddock confine their spawning so definitely to smooth bottom in American as in European seas, for Welsh found ripe fish chiefly on broken ground "wherever sand, gravel, mud and rocks alternate—if anything, more are taken on the mud in such localities," between Cape Ann and Cape Elizabeth.

The Gulf of Maine haddock spawn chiefly from late February until May, and the following record, supplied by C. G. Corliss, superintendent of the local hatchery, will illustrate the brief duration of the peak of the period of reproduction for the neighborhood of Gloucester:

Year	First eggs taken	Last eggs taken	Period of greatest abundance	Total eggs collected
1917	Apr. 16	May 3		10, 820, 000
1918	Mar. 22	Apr. 24	Apr. 9 to Apr. 23	32, 380, 000
1919	Feb. 12	Apr. 30	Feb. 20 to Apr. 23	332, 740, 000
1920	Jan. 20	Apr. 29	Mar. 25 to Apr. 25	303, 380, 000
1921	Jan. 22	Apr. 25	Jan. 27 to Apr. 14	629, 130, 000

It appears from the hatchery records, corroborated by Welsh's experience in 1913, that the commencement of spawning varies considerably in date from year to year, the fish breeding freely as early as the end of January in early seasons but not until the end of March or even the first part of April in late seasons. The bulk of them, however, are invariably spawned out by the middle or end of May at the latest. The spawning season is apparently the same on Georges Bank as in the inner waters of the Gulf, for we found cod-haddock eggs in moderate numbers across its western end late in February, great numbers of them (and took ripe haddock in the trawl) on the eastern end on March 11 and 12, and they were still plentiful there on April 16 and 17. Similarly, Mr. Douthart, of the Bureau of Fisheries, towed haddock eggs over the north-central portion of the bank on April 14 and again on the 26th and 27th, in 1913, but the *Albatross* found none on the western part of the bank on May 17 in 1920.

Spawning is likewise at its height in mid-April on Browns Bank (large egg catches in our tow nets April 16, 1920). Although ripe haddock have occasionally been taken near Gloucester as late as the first half of July [7] this is quite exceptional, and since our latest egg date is June 10 (Petit Passage, Nova Scotia) it is unlikely that haddock spawn regularly anywhere west of Cape Sable after the middle of that month. The spawning season continues later into the summer in the colder water along the southern shores of Nova Scotia, for we took several unmistakable haddock among numerous newly spawned cod or haddock eggs a few miles off Shelburne on June 23, 1915, while Dannevig [8] records occasional haddock larvæ off Halifax on July 23, near Cape Sable Island on July 25 and 26, and on St. Pierre Bank on July 27 and 28 for that same summer.

The breeding season is the same in European as in American seas—that is, end of January until late June—with the peak of production falling as early as March and April in the North Sea region but not until June around Iceland.[9]

Temperature and salinity.—The Georges and Browns Bank haddock spawn in temperatures ranging from about 36.5° to about 42° to 43°, and the whole spawning period on the coastwise grounds between Cape Cod and Cape Elizabeth is likewise completed before the stratum of water in which the fish are lying has warmed more

[7] Earll, 1880, p. 730.

[8] Canadian Fisheries Expedition, 1914-15 (1919), p. 21.

[9] Damas, Rapports et Procès-Verbaux, Conséil International pour l'Exploration de la Mer, Vol. X, 1909, Schmidt, *ibid.*

than a few degrees from its coldest for the year—that is to say, in temperatures of 35 to 40°. Allowing for annual variations, this gives an extreme range of from about 35° to about 44° for the most active spawning over the Gulf of Maine as a whole, temperatures considerably lower than those in which haddock spawn in European waters (41 to 50°).

The Gulf of Maine haddock likewise breeds in fresher water than does its European congener and necessarily so, for the parts of the Gulf where haddock breed are decidedly less saline at all levels and seasons than the spawning grounds in the North Sea, around the Faroe Islands, or south and west of Iceland. Thus whether it be on Georges Bank or Browns Bank or on the coastal grounds, most of the spawning takes place in salinities of 32 to 32.5 per mille, with 34.5 per mille as about the maximum for fish spawning deepest on the offshore slope of Georges Bank, and 31 per mille the minimum, whereas haddock in north European waters spawn chiefly in water as saline as 34.5 to 35.5 per mille.

Density of water.—The specific gravity of the water (the factor that determines whether buoyant fish eggs float and develop or sink and die) is usually between 1.0255 and 1.0260 in the Gulf at the levels where fish live, both on the offshore banks and along shore. So far as is known no haddock eggs are actually spawned in water lighter than this and few in water as heavy as 1.0270, but the overlying water may be very much fresher, and is often so light near shore at the time of the spring freshets as to interfere with the operation of the hatcheries. Eggs artificially fertilized on board the *Albatross* off Gloucester in May, 1913, proved to be very nearly balanced in water of a specific gravity of 1.0232, with 1.0230 the critical density for unfertilized as well as for fertilized and developing eggs, a result justifying the hypothesis that in whatever part of the Gulf haddock eggs are deposited they will rise from the bottom; and if they fail to reach the surface locally because of its low density, they will merely float, balanced in the water, a few fathoms down. Furthermore it is probable that eggs naturally spawned gradually lose in specific gravity as they float upward into lighter and lighter water.[10] In short, there is no reason to suppose that any of the haddock eggs produced in the Gulf are lost by sinking, to smother on the bottom.

The eggs of the haddock are buoyant, without oil globule, and from 1.19 to 1.72 mm. in diameter. Eggs taken at Gloucester in March, 1913, averaged 1.57 mm., varying from 1.47 to 1.72 mm. Thus they average slightly larger than those of the cod. In early stages in development the haddock egg can not be distinguished from that of the cod, hence the term "cod-haddock," and when first spawned there is even danger of confusing them with the eggs of one of our commonest flounders—the "witch" (p. 515), whose breeding season immediately succeeds that of the haddock. The formation of black pigment, however, identifies the cod-haddock egg as such (the embryonic pigment of the "witch" is yellow), and shortly before hatching, when the embryo is as long as the circumference of the yolk, the characteristic arrangement of the pigment granules marks it either as cod or as haddock, as explained below (p. 444).

[10] We base this statement on the fact that there were about as many eggs floating on the surface as at 10 to 15 or 40 meters at the station where the experiment just mentioned was carried out, although artificially fertilized eggs sank in water dipped from the surface.

The haddock, like the cod, is a very prolific fish for its size. Earll (1880) estimated the number of eggs in a female of 19¼ inches at 169,050, with 634,380 in a 9¾-pound fish and 1,839,581 in one 28½ inches long and weighing 9 pounds 9 ounces. At a temperature of 37° incubation occupies 15 days, and 13 days at 41°—a fair average for eggs spawned in the Gulf of Maine. The newly hatched larva is about 4 mm. long, with the vent close behind the yolk sac and at the base, not the margin, of the ventral fin fold, thus apparently ending blind. It resembles a cod so closely that the two would be indistinguishable were it not that the post-anal pigment of the haddock is arranged in a row along the ventral surface of the trunk from vent to tip of tail and not in bands as it is in cod and American pollock, while the dorsal wall of the body cavity is likewise densely pigmented, the arrangement of the larval pigment serving to differentiate the little haddock until it is about 12 mm. long. In water of 41° the yolk sac is absorbed in about 10 days when the little fish is about 5.5 mm. long, the dorsal and anal fin rays appear at about 11 mm., these fins are fully formed at 16 to 20 mm., and at 30 to 40 mm. the young haddock begin to take on the general aspect of the adult. Fry of 20 to 30 mm. are easily distinguished from both cod and pollock by their pale pigmentation and by the greater height of the first dorsal fin.

154. **Blue hake** (*Antimora viola* Goode and Bean)

Jordan and Evermann, 1896–1900, p. 2544.

Description.—This species resembles the white and squirrel hakes in the form of its body and in the presence of two separate dorsal fins, the first very short and the second very long; but it is readily distinguished from them by the fact that the anal fin is so deeply notched about midway of its length that there are apparently two separate fins, and that each ventral fin is 6-rayed though with the second ray elongate and filamentous. The form of the snout, which is flattened above, keeled at the sides, and rounded at the tip, is likewise distinctive. The vent is situated much farther back than in the true hakes (genus Urophycis), and the color is deep violet or blue black.

Occurrence.—The blue hake has been reported at so many localities on the continental slope off southern New England, eastward to the Grand Banks, that it must be one of the most plentiful of fishes there at 350 to 1,000 fathoms. Halibut fishermen have occasionally brought it in, but it has not been taken within the limits of the Gulf of Maine and is hardly to be expected there, the shoalest capture recorded so far being from 306 fathoms.

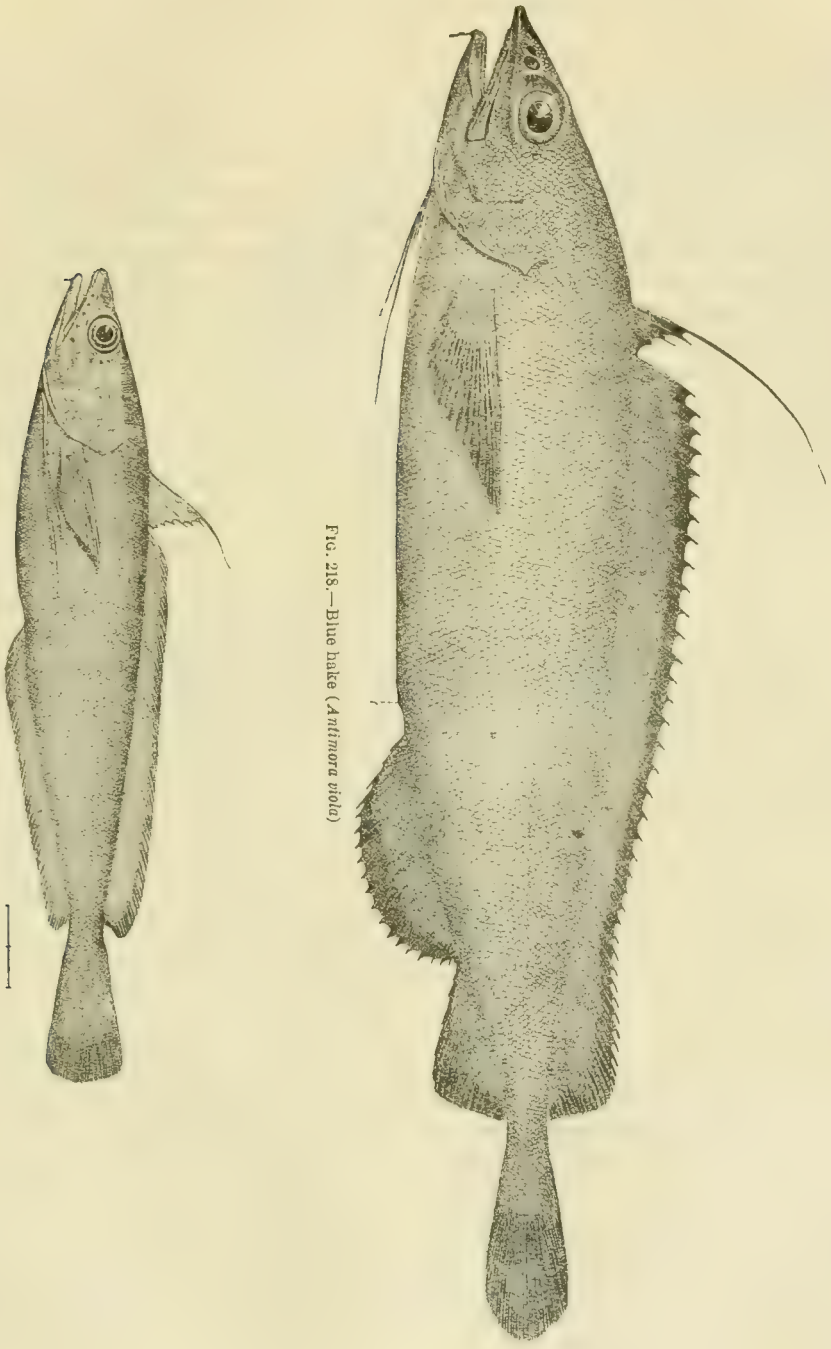

FIG. 218.—Blue hake (*Antimora viola*)

FIG. 219.—White hake (*Urophycis tenuis*)

155. White hake (*Urophycis tenuis* Mitchill)[11]

BOSTON HAKE; BLACK HAKE; MUD HAKE; HAKE; LING

Jordan and Evermann, 1896–1900, p. 2555.

Description.—Although the hakes of the genus Urophycis ("true hakes" in general parlance on this side of the Atlantic) are close relatives of the cod and haddock, they are not at all codlike in appearance, being more slender and softer-bodied fish, tapering backward from the shoulders to a slim caudal peduncle and small weak tail, with much larger eyes but smaller chin barbels. There are only two dorsal fins—the second many times longer than the first—and one anal fin, instead of the three dorsals and two anals of the pollock, cod, and haddock. Furthermore the ventrals are long, narrow, and feelerlike. The body of the white hake is rounded in front of the vent, compressed behind it, and about five and one-half times as long as deep. The mouth is so wide that it gapes back to below the eyes, the upper jaw projects beyond the lower, and the chin bears a small barbel. The first dorsal fin (9 to 10 rays) originates over the shoulders close behind the pectorals and is shorter than the latter, triangular, the tip of its third ray elongate and filamentous at the tip, with the free part longer than the fin proper is high. The second dorsal (about 54 to 57 rays) runs the whole length of the trunk from close behind the first dorsal to the caudal peduncle, is of about equal height from end to end, with rounded corners, and is only about half as high as the first dorsal. The anal is similar in outline to the second dorsal but shorter (about 48 to 50 rays). The pectorals are rounded when spread; the ventrals, which are situated considerably in front of the pectorals, are reduced to two very much elongate rays each (apparently one branched ray), the lower (longer) falling slightly short of the vent; and their length has often been given as a diagnostic character separating this from the squirrel hake (p. 447), in which they are usually described as reaching beyond the vent. We can verify Goode's (et al., 1884) statement that this distinction is not to be relied on, however, having seen squirrel hakes in which the ventrals lacked something of reaching the vent. The scales on both head and body are smaller than those of the closely allied squirrel hake, and their number is the most reliable distinction between the two species, there being about 140 oblique rows of scales between gill opening and base of tail fin in the white hake and seldom (if ever) more than 110 rows of scales in the squirrel hake.

Color.—Like most bottom fish hake vary in color. As a rule they are muddy or reddish brown above, sometimes almost slaty (I saw one of this shade caught in Northeast Harbor, Me.), the sides sometimes bronzed, and the belly dirty or yellowish white peppered with tiny black dots. The dorsal fins are of the same color as the back, the anal the same as the belly, and both black edged. The ventrals are likewise pale like the belly but usually more tinged with yellow.

Size.—The maximum length is about 3½ feet, the weight 30 pounds, but most of the fish caught are between 1 and 20 pounds, averaging no more than 5 to 8 pounds. A hake 28 inches long will "go" about 8½ pounds if in good condition; 30 inches, 9 pounds; 36 to 38 inches, 13 to 16 pounds; and about 18 pounds at 40 inches, according to Welsh's experience.

[11] The European "hake" is Merluccius (p. 386).

156. Squirrel hake (*Urophycis chuss* Walbaum)

HAKE

Jordan and Evermann, 1896–1900, p. 2555.

Description.—The "squirrel" so closely resembles the white hake (p. 446) that the one is often taken for the other. The number of scales affords the most reliable means of identification, those of the "squirrel" being much larger and arranged in about 100 to 110 oblique cross rows along the side from gill opening to base of caudal fin, and in only about 9 longitudinal rows on the upper sides between lateral line and dorsal fin, as against about 140 transverse and 12 longitudinal rows, respectively, in the white hake (p. 446). The ventral fins of the "squirrel" overlap the vent as a rule, whereas those of the white hake fall short of it, but, as already remarked, this is not invariably the case for we ourselves have seen "squirrels" with ventrals failing to reach the vent. Furthermore the filamentous part of the third ray of the first dorsal is much longer (if undamaged) in the "squirrel" than in the white hake—that is, three to five times as long as the rest of the fin—and the nose is blunter. The number of fin rays is about the same in the two species.

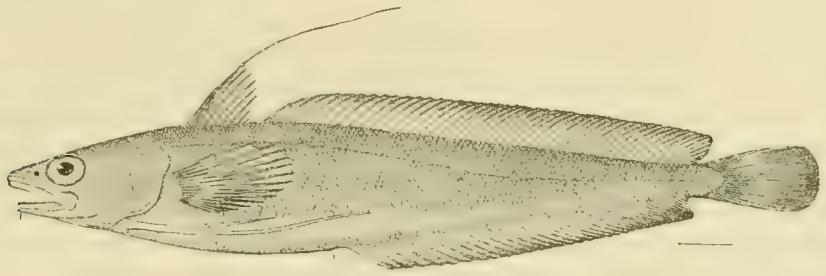

FIG 220.—Squirrel hake (*Urophycis chuss*)

Color.—The squirrel hake is reddish, muddy, or olive brown on sides and back, darkest above, sometimes almost black, sometimes more or less mottled, and sometimes plain, with pale lateral line, its lower sides usually washed with yellowish and sometimes dusky dotted. Its belly and the lower sides of its head are pure white, grayish, or yellowish; its dorsal, caudal, and anal fins are of the same color as the back except that the latter is pale at the base. The ventrals are very pale pinkish or yellowish.

Size.—The "squirrel" does not grow to as large a size as the white hake, seldom reaching a greater length than 30 inches (the largest of 780 Bay of Fundy fish measured by Craigie was about 27 inches long), or greater weight than 6 to 8 pounds. The average of the commercial catch will not run above 2 to 5 pounds. Females are both longer and heavier than males of the same age (p. 452).

We are forced to discuss these two hakes together for they are so hard to distinguish, one from the other, that few fishermen recognize the existence of more than one kind—in fact it is not unlikely that they intergrade—and they agree so closely in distribution and habits that what is said of one applies equally to the other except for their spawning (p. 452).

General range.—Both these hakes are exclusively American, occurring on the continental shelf from the Gulf of St. Lawrence and banks of Newfoundland to the Middle Atlantic States, the "squirrel," at least, being common as far south as Chesapeake Bay.[12] The most southerly record for it is off Virginia, while the white hake has been reported off North Carolina, but very likely the former actually ranges as far south as the latter. Both are bottom fish, occurring from near tide mark down to about 300 fathoms.

Occurrence in the Gulf of Maine.—These two hakes are very common fish in the Gulf, where they are regularly caught side by side, and since the fishery returns are simply for "hake" it is impossible to distinguish between them either with regard to local distribution or to relative abundance. On the whole, however, the white hake seems the more plentiful of the two in the Bay of Fundy, while our own inquiries of fishermen, corroborated by personal experience, suggests that this applies generally to the deep parts of the Gulf below 30 to 40 fathoms—for instance to the deeper holes in Massachusetts Bay—and both Storer and Goode and Bean (1879) spoke of the "white" as the more common of the two there. In Ipswich Bay, on the other hand, we trawled 34 squirrel and only two other hake [13] in 22 fathoms on one occasion in July, 1912, and Welsh counted 6,450 squirrel to 652 white hake caught in the otter trawl on the northwest slope of Georges Bank in June, 1912. The fact that our Gulf yielded something like 35,000,000 pounds [14] of the two species combined in 1919 illustrates how plentiful hake are there.

Both these common hakes dwell chiefly on soft bottom, few being caught on the gravelly or shelly grounds so prolific of cod and haddocks, and neither species is taken among rocks. We believe from our own experience that the white hake is more strictly a mud fish than is the "squirrel." The difference in the types of bottom frequented by hake on the one hand and by cod and haddock on the other is clearly reflected in the statistics of the catches, for Georges Bank contributed only about 112,000 pounds and Browns less than 90,000 pounds of hake to the total just mentioned. No doubt these few fish were caught well down the slopes, fishermen assuring us that it is rare to catch a hake on the shoaler hard-bottomed parts of the banks, whereas they are found very plentiful when a line trawl runs off in deeper water, particularly off the northwest face of Georges Bank, and it has long been well known that there is an abundance of them all along the southern slope of the bank below 60 to 70 fathoms. Hake are also very plentiful in the South Channel, whence about 2,000,000 pounds were landed in 1919, and they are so abundant on the lower slopes of all the banks and ledges in the inner parts of the Gulf, as well as on the soft mud floors between them, that many are taken all around the coastal belt wherever the bottom is suitable. Massachusetts Bay, for example, yielded no less than 750,000 pounds for the year in question, but hake, like cod, become scarce going up the Bay of Fundy, as the fishery returns prove.

The chief centers of abundance inshore lie off the southwestern coast of Nova Scotia, at the mouth of the Bay of Fundy, along the coast of Maine between Machias

[12] Field notes by W. C. Schroeder, of the U. S. Bureau of Fisheries.

[13] The latter were listed by Welsh as *U. regius*, but probably they were actually white hake.

[14] The exact figure can not be given because hake are combined with cusk in the Canadian returns.

and Mount Desert, in Frenchman's Bay (formerly the site of an important hake fishery), likewise the ground known locally as the "grumpy" near Isle au Haut, and off Penobscot Bay. Sundry small grounds outside the islands, thence to Cape Elizabeth, and all along the western side of the Gulf also yield good numbers of hake, especially Ipswich Bay and the neighborhood of the Isles of Shoals, a famous haking ground to which small-boat fishermen repair. Good catches are also made near Boon Island on soft bottom between the hard patches, on the lower slopes of Jeffreys and Stellwagen Banks, and to a less extent on Platts. Hake, with flounders and rosefish, are practically the only commerical species one is apt to catch on the floors of the deep basins and sinks, and a catch of 2,880 of the former with 580 cusk, but no cod or haddock, made by a line trawler 15 miles southeast of Monhegan on June 24 to 25, 1913, will illustrate how completely they monopolize suitable bottoms.

No doubt the stock of hake (white and squirrel combined) inhabiting the Gulf fluctuates from year to year (this is true of any fish), but statistics of the catches do not show any signs of depletion, the annual landings in the New England States having seldom fallen as low as 20,000,000 or risen above 35,000,000 pounds for the past 25 years.

The range of depth occupied by the hakes is considerable and varies with the age of the fish. Like many other sea fish they spend their first months at or near the surface, living pelagic, and fry of ½ to 4 inches (among which both species are no doubt represented [15]) are often taken in summer under floating eelgrass or rockweed. On calm days we have seen them darting to and fro on the surface (p. 454), but it is evident that the duration of this pelagic stage varies, for we have towed fry as long as 4 inches on the surface although others seek the bottom while still only 2 inches long. Nor is it known how far they may journey while at the mercy of currents. When hake first take to bottom many of them do so in very shallow water, fry 2 to 6 inches long being common close below tide mark in eelgrass, and fish a little larger are often caught by flounder fishermen in the harbors around the Gulf of Maine. Others, however, seek the ground in somewhat deeper water where they have an interesting habit of hiding within the living shells of the giant scallop (*Pecten magellanicus*). This has been observed most often on the outer part of the continental shelf off southern New England, but scallop fishermen have informed us that they frequently find little hake in scallops dredged off the coast of Maine. Both the common species of hake are known to use this curious refuge (they do not feed on the scallops but merely use their shells as a hiding place), but most of the specimens so taken have proved to be "squirrels." So commonly does the latter adopt this form of commensalism that Welsh records as many as 27 taken from 59 scallops in one haul of the scallop dredge, 11 hake from 9 scallops in another, besides many others not counted off southern New England, New York, and New Jersey during the summer and autumn of 1913.

Immature hake of slightly larger sizes (that is, up to 8 to 12 inches long) are rather common close inshore in a fathom or two of water, in harbors, and even well

[15] The youngest stages of the two species are so much alike that in most cases we have been forced to list them simply as hake, awaiting more critical examination than we have been able to afford them.

up estuaries all around the Gulf from Massachusetts Bay on the one side to the Bay of Fundy on the other, as well as offshore; but the larger fish usually keep to deeper water, especially in summer, when hake of marketable sizes are most plentiful below 20 fathoms, and when few large ones are caught in less than 10 fathoms of water. But this rule, like most others, has its exceptions. For instance, I saw a white hake of about 8 pounds taken from a float in Northeast Harbor, Me., in about 10 feet of water in July, 1922. On the other hand, hake are to be caught in the deepest parts of the Gulf, and white hake have been taken down to 304 fathoms on the offshore slope of Georges Bank.

A more or less regular inshore movement of hake is said to take place in autumn, especially in the northeastern part of the Gulf, resulting in the capture of considerable numbers in the deeper muddy harbors and bays east of Penobscot Bay during the winter. They not only enter St. John Harbor during autumn, but run up the St. John River to Kennebecasis Bay, where they are caught all winter through the ice, and they carry out corresponding in and off shore movements off southern New England, to which the appearance of goodly numbers in shoal water at Woods Hole in autumn bears witness. On the other hand, they enter Passamaquoddy Bay in early summer, to depart in autumn. Probably the truth is that the adults are cool-water fish and are barred from the shallows in summer by high temperature, but that the low summer temperature allows them to summer in Passamaquoddy Bay. Their departure thence in autumn has not yet been accounted for. Except for these in and off shore movements and for the involuntary migrations of the larvæ and for young fry while living at the surface, hake are resident throughout the year in the open Gulf of Maine wherever found, and they are much more stationary than either cod or haddock.

Food.—Less is known of the diet of the hakes than of cod, haddock, or pollock. However, it is certain that they are not shell eaters to any extent, for it is seldom that their stomachs contain even the smaller univalves or bivalves, and so far as we know no one has ever found large mollusks, echinoderms, nor any of the large hard-shelled crustaceans (e. g., rock crabs or lobsters), in a hake. The stomach contents so far recorded [16] show that prawns (Pandalus), shrimps, amphipods, and other small Crustacea which they find on the bottom are their chief dependence at most times and localities. They also feed as greedily on squid as do others of the cod tribe, while a variety of small fish have been found in hake stomachs at Woods Hole,[17] among them alewives, butterfish, cunners, eels, flatfish, tautog, herring, mackerel, menhaden, launce, silversides, silver hake, sculpins, sea robins, smelt, and tomcod. They bite fish bait readily—in fact the greater part of the catch is taken on line trawls baited with herring. They also take clams on the hook greedily enough.

[16] Goode, et al. (1884), Kendall (1898, p. 180), Linton (Bulletin, United States Fish Commission, Vol. XIX, 1899 (1901), p. 478), Hansen (Proceedings, U. S. National Museum, vol. 48, 1915, p. 94), Breder (Zoologica (New York), Vol. II, No. 15, August 15, 1922, p. 350) and Vinal Edwards's notes.

[17] A large white hake taken at Woods Hole in May, 1908, had a fish (Lepophidium) encysted in the wall of its body cavity, it having no doubt penetrated the hake's stomach after it had been swallowed (Bulletin, U. S. Bureau of Fisheries, Vol. XXXI, Part II, 1911 (1913), p. 768).

In the northeastern part of the Gulf hake feed far enough off bottom to capture the pelagic euphausiid shrimps (Meganyctiphanes and Thysanoessa) so plentiful there, while the general character of their diet is sufficient evidence that they do not root in the ground like haddock. Ever since 1616, when Capt. John Smith (1616, ed. 1819, vol. 2, p. 188) wrote "Hake you may have when the cod failes in summer, if you will fish in the night," it has been common knowledge that they bite best after dark, from which it is fair to assume they do most of their foraging between sunset and sunrise.

Herrick [18] has given an interesting account of the habits and perceptions of squirrel hake in the tank at Woods Hole, where they proved to have keen sight, though less so than pollock, and usually caught bits of meat before they sank, but it seems that it was only while food was in motion that the fish recognized it by sight and that they depend chiefly on the sense of touch for their livelihood. This they

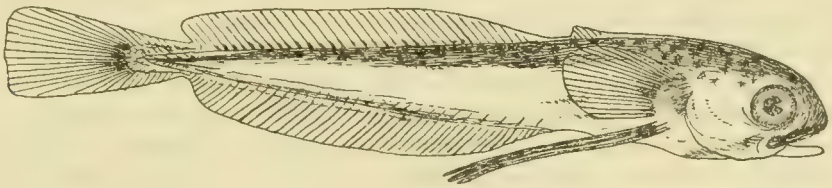

FIG. 221.—Hake fry (Urophycis), 15 millimeters. After A. Agassiz

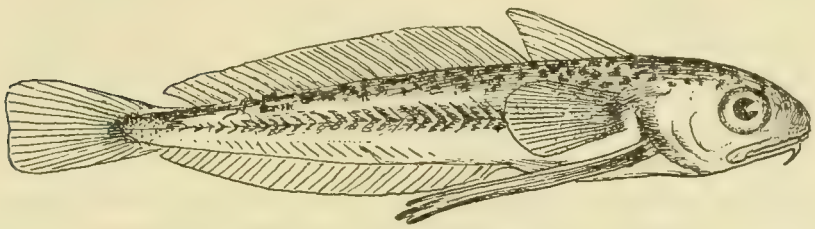

FIG. 222.—Hake fry (Urophycis), 34 millimeters. After A. Agassiz

exercised by swimming close to bottom with the sensitive tips of the ventral fins dragging the ground, and when a hake thus touched a fragment of clam, it immediately recognized its palatability and snapped it up, but not otherwise, while they paid no attention whatever to live clams in their shells, though frequently brushing over them. These observations, applied to the conditions under which hake actually live, suggest that they not only recognize shrimps, prawns, etc., by their ventral feelers, but disturb them by the passage of the feelers over them, snapping them up as they dart ahead.

Rate of growth.—The rate of growth during the first few months can not be stated until many more young fry have been measured and identified as one species or the other. It is probable that two year classes are represented among the fry caught along shore in summer, the smaller of 2 to 3 inches being from the earliest spawned eggs of that season, and the larger ones (6 to 7 inches) yearlings. The

[18] Bulletin, United States Fish Commission, Vol. XXII, 1902 (1904), p. 258.

growth of older squirrel hake in the Bay of Fundy has been studied by Craigie (1916, p. 87), his conclusions from scale studies,[19] combined with measurements, being as follows:

	Average length, inches
1-year-old male	7. 9
1-year-old female	8. 3
2-year-old male	13
2-year-old female	14. 2
3-year-old male	16. 1
3-year-old female	18. 5

The rate of growth is so uniform during the first three years of life, that spawning (an event so exhausting that it slows the growth of any fish) probably does not take place until the fourth year. Nothing definite is known of the rate of growth of the white hake, but it is fair to assume that it grows faster than the squirrel, to attain so much greater length and weight.

Breeding habits.—Practically nothing is known of the breeding habits of the white hake, but Welsh's examination of fish caught near Gloucester led him to conclude that spawning takes place in fall and winter and occasionally as late as April (he saw a male with the milt flowing on April 22, 1913).[20] The egg is no doubt pelagic like that of the squirrel hake (p. 453), but no ripe females, eggs, or young larvæ have ever been seen.

Up to the summer of 1912 we were equally ignorant of the spawning and early stages of the squirrel hake. In that July, however, we trawled squirrel hake with running spawn and milt in Ipswich Bay, fertilizing the eggs on board the *Grampus* and thus identifying eggs taken in abundance in the tow as this species. Since that time large numbers of squirrel-hake eggs have been fertilized artificially and hatched at the Gloucester hatchery.

The height of the spawning season of this species falls in early summer in the Massachusetts Bay region and at least as early as June south of Cape Cod, judging from the size (27 to 70 mm.) of the fry just mentioned as found in scallop shells in late summer and autumn (p. 449). The extreme limits of the season are not known, but we have towed eggs of this species as early as June 10 (in Petit Passage) and as late as September 20 in various parts of the Gulf, while captures of fry of 72 mm. as early as the last week in July (in Shelburne Harbor) and others as small as 36 mm. in the western part of the Gulf as late as November 1 (in 1916), similarly point to a breeding season lasting from late spring until early autumn.

The localities where we have found eggs, provisionally identified as squirrel hake in the tow (fig. 223), show that it spawns all around the Gulf from Cape Cod to Nova Scotia, and in spite of its rather deep-water habitat and preference for soft bottom most of these egg stations, like those for the other common gadoids, are in shoal water near the coast, a haul in the eastern basin, which yielded both squirrel hake and silver hake eggs (p. 392) being the only exception. This, of course, points to a migration from the basins into shoaler water for spawning, but our records are

[19] Unfortunately hake scales do not show the annual rings as clearly as those of cod and haddock.

[20] Tracy (1910, p. 157) is also of the opinion that this hake is a winter spawner.

not sufficiently numerous nor is the identification of the eggs certain enough to prove it. Neither can we establish the temperatures or salinities in which it spawns most freely from the data yet gathered.

The eggs are buoyant, spherical, transparent, and 0.72 to 0.76 mm. in diameter. When first spawned there are variable numbers of small colorless oil globules 0.02 to 0.07 mm. in diameter scattered over the yolk, but shortly after fertilization has taken place most of these globules unite into one large one of 0.15 to 0.17 mm., which is sometimes alone but usually has two or three tiny ones close beside it. Within two

FIG. 223.—Locality records for squirrel hake eggs (●) and for larvæ of rockling (▲) in the Gulf of Maine

days after fertilization (at a temperature of 60°) the embryo extends half way around the yolk sphere and pigment has appeared, one of the most characteristic features of this species being the development of black chromatophores not only on the embryo but over the yolk and finally on the oil globule as well. In late stages of incubation this feature, combined with the small size of the egg and (usually) with a multiple oil globule, distinguishes the egg of the squirrel hake from all other buoyant fish eggs of known parentage yet found in the Gulf, except that of the rockling (p. 461), which is of

about the same size with several oil globules (p. 461). The yolk of the North Sea rockling is colorless, which fact, if it were the universal rule, would be a sufficient distinction between the two species; but it is sometimes pigmented in rockling eggs in the Baltic,[21] and since rockling eggs have not yet been carried through to hatching in the Gulf of Maine it remains to be seen whether the presence or absence of pigment on the yolk can be depended on to separate its egg from that of the hake. There is also a danger of confounding newly spawned eggs of the squirrel hake with those of the butterfish (p. 248), which are about the same diameter, but as a rule the number and size of the oil globules is diagnostic.

The larval stages of the squirrel hake still remain unknown, nor have its pelagic fry been described under their own name; but fry figured by Alexander Agassiz (1882, Pl. VII, fig. 6; Pl. VIII, figs. 1–3) as "*Motella argentata*" [22] were undoubtedly one or the other of our hakes, for they showed the long ventrals, the two dorsal fins,

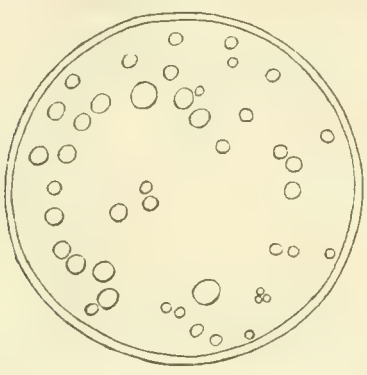

FIG. 224.—Egg of the squirrel hake (*Urophycis chuss*), after 1 hour's incubation

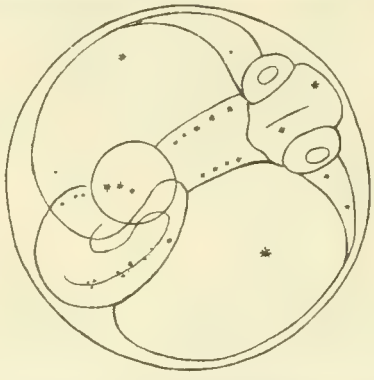

FIG. 225.—Egg of the squirrel hake (*Urophycis chuss*), after 74 hours' incubation

and the single barbel of the latter and agreed perfectly with the hake fry we ourselves have taken. The young of these little hakes, which are greenish blue on the back with silvery sides, are separable from rockling by their more elongate form and by the arrangement of the pigment, which is not in a band but scattered (this requires verification on larger series of specimens). Older stages are identified by the presence of two well-developed dorsal fins, and the silvery sides mark them at a glance from the dull-colored fry of the cusk (p. 466).

Commercial importance.—Though soft-meated, both the common hakes—"squirrel" and "white"— are excellent table fish and are readily absorbed by the market. The greater parts of the catch is made on line trawls.

[21] Agassiz and Whitman (1885, p. 24), provisionally identified as "rockling" certain eggs with pigmented yolk taken in the tow net at Newport, but they may have been hake.

[22] The single post-anal pigment band, short stocky form, and fanlike ventrals of the younger larval stages (Pl. VII, figs. 1–4) which he pictured under this name suggest identity with the four-bearded rockling.

157. Spotted hake (*Urophycis regius* Walbaum)

Jordan and Evermann, 1896–1900, p. 2553.

Description.—This species is distinguishable among the hakes of the Gulf of Maine by the fact that there are no elongate rays in its first dorsal fin (which is hardly higher than the second dorsal), the fin rays are fewer in number than in either white or squirrel hake (only about 8 and 43 dorsal and 40 anal, as against 9 and about 57 dorsal and 48 to 50 anal), and that there are only 80 to 90 vertical rows of scales from gill opening to caudal fin. Convenient field marks are that the pectoral of the spotted hake reaches as far back as the origin of the anal, whereas in both white and squirrel hakes it falls considerably short of the latter, and that its lateral line is darker brown than the general body color, instead of paler, and interrupted by a series of distinct whitish spots. Otherwise the spotted hake, like the commoner hakes, is dull brown, darker above than below, with vertical fins of the same color as the back. The outer half of the first dorsal is black with whitish margin, and the ventrals are whitish.

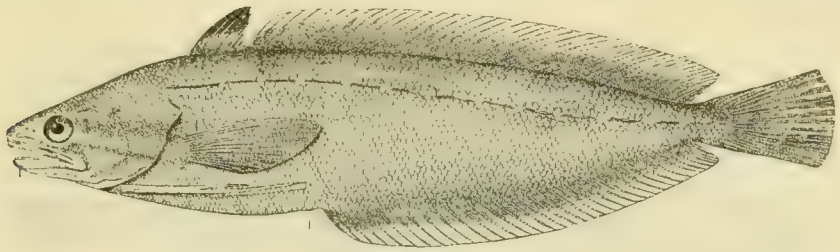

FIG. 226.—Spotted hake (*Urophycis regius*)

Size.—This is a smaller fish than the white hake (p. 446), the largest of many measured by Welsh at Atlantic City (N. J.) in August, 1920, being only 16 inches long and weighing between 1 and 1½ pounds.

General range and occurrence in the Gulf of Maine.—The spotted hake is a more southern species than the white or squirrel hakes—commonest off the Middle Atlantic States—and though it is known off the coast of North America from Cape Fear (N. C.) to Halifax (Nova Scotia), it so rarely strays north of Cape Cod that specimens taken off Seguin Island many years ago still remain the only definite record of it for the Gulf of Maine,[23] while it is scarce even at Woods Hole.

Habits.—The spotted hake resembles the other hakes in its habits, but apparently it is more of a fish eater, for Vinal Edwards noted that the few he examined at Woods Hole contained alewives, menhaden, launce, and squid, but none of the crustaceans on which the white and squirrel hake feed. The capture of spawning fish by the *Albatross* off the coast of the Carolinas in December, 1919, recorded in Welsh's field notes, is evidence that it is a winter breeder.

[23] This species was also listed from Ipswich Bay, Casco Bay, and off Monhegan Island in the *Grampus* collections of 1912 (Bulletin, Museum of Comparative Zoology at Harvard College, Vol. LVIII, No. 2, 1914, p. 113), but it is probable that in reality these specimens were white hake (p. 448).

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158. **Long-finned hake** (*Urophycis chesteri* Goode and Bean)

Jordan and Evermann, 1896–1900, p. 2556.

Description.—The most distinctive characters of the long-finned hake are its enormously elongate ventrals, for the longer of the three rays to which each of these is reduced reaches back nearly to the rear end of the anal fin (about to its fortieth ray), with the next longest ventral ray considerably overlapping the anal. The filamentous dorsal ray is also longer than in the other Gulf of Maine hakes, reaching back to about the middle of the second dorsal. Furthermore, there are only about 90 vertical rows of scales from gill opening to tail, but the scales themselves are relatively larger than in either the white or the squirrel hake, the eye larger, the anal fin rays more numerous (about 56), the rear corners of the dorsal and anal fins more rounded, the outline of the latter concave instead of straight (fig. 227), the pectoral fins more slender and more pointed, and the caudal fin narrower and its margin more convex—differences more clearly shown in the illustrations than verbally. The skin of the long-finned hake is curiously loose like that of many deep-sea fishes.

FIG. 227.—Long-finned hake (*Urophycis chesteri*)

Color.—The color of this hake has never been described from life and unfortunately no color notes were made from the only specimen we have seen freshly caught. Old alcoholic specimens are of varying shades of dull red and reddish brown above, dirty or reddish white below, with the caudal fin sooty at its tip, the dorsals of the same color as the back, but with dusky margins, the pectorals and ventrals colorless except that the latter are minutely specked with sooty dots.

Size.—The collection of the Museum of Comparative Zoology contains specimens up to 10½ or 11 inches long, which are the largest so far recorded.

General range.—This is a deep-water fish, occurring in great abundance on the continental slope off North America from the Laurentian Channel to abreast of Cape Lookout (N. C.), chiefly between 100 and 500 fathoms. The shoalest capture of the adult recorded is from 32 fathoms, the deepest from 538 fathoms.

Occurrence in the Gulf of Maine.—This hake is plentiful all along the seaward slope of Georges Bank below 100 fathoms, where it has been trawled at many stations,[24] and is rivaled in abundance only by the grenadier (*Macrourus bairdii*, p. 468), so that it may be expected on the bottom of the deep trough of the Gulf of Maine.

[24] For a complete list of localities see Goode and Bean (1896, p. 361).

So far, however, the only definite record of it within the latter is for three specimens trawled in the Western Basin, 41 and 33 miles off Cape Ann,[25] in 110 to 140 fathoms in 1878.

Habits.—Nothing is known of the habits of the long-finned hake except that it is a bottom fish and seems never to come up into shallow water. It is a summer and autumn spawner, judging from the fact that Goode and Bean saw specimens in breeding condition and that we have taken pelagic young of 8 to 35 mm. in our tows off Marthas Vineyard during the last week of August.[26]

159. **Hakeling** (*Physiculus fulvus* Bean)

Jordan and Evermann, 1896–1900, p. 2547.

Description.—This species is hakelike in general appearance and in the general arrangement of its fins—that is, it has two dorsals, the first (10 rays) triangular and much shorter than the second (about 49 rays) which is of nearly uniform height from end to end; one long anal fin (about 54 rays) similar to the second dorsal; and ventrals

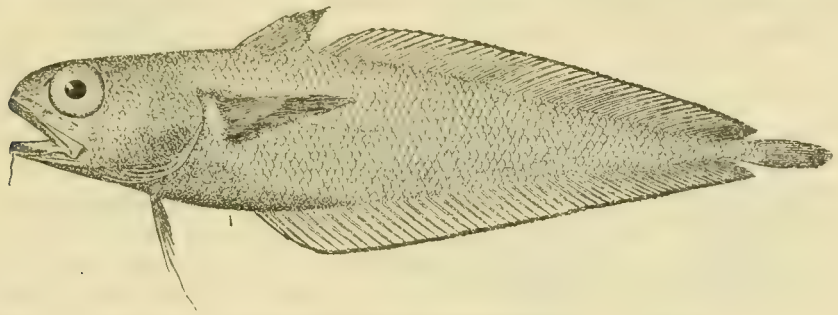

FIG. 228.—Hakeling (*Physiculus fulvus*)

situated in front of the pectorals. It is separable from the white, squirrel, and long-finned hakes (genus Urophycis, pp. 446, 447, and 454) by the fact that its anal fin originates in front of the origin of the second dorsal instead of considerably behind it, while its ventral fins have 5 rays each instead of only 2 and are so much shorter than those of the hakes that even their longest ray (the second, which is filamentous at the tip) hardly reaches back as far as the middle of the pectorals. Furthermore, the snout of the hakeling is blunter than that of any hake, its caudal fin much smaller, its general form more abruptly tapering, and none of the rays of its first dorsal fin are elongate.

Color.—Described (Goode and Bean, 1896) as light yellowish brown with the lower surface of the head, the abdomen, and the margins of the dorsal and anal fins very dark brown, and with a dark brown blotch on each cheek (on the suboperculum).

Size.—The size to which this species grows is not known.

General range and occurrence in the Gulf of Maine.—This hakeling has been taken at several localities in the Gulf of Mexico and on the continental slope off the eastern

[25] These were the basis of Goode and Bean's original description of the species (1879c, p. 256).
[26] Bigelow, 1917, p. 275.

United States. The most northerly record is off Nantucket (lat. 40° 1′ N., long. 69° 56′ W.) in 79 fathoms, and it is on the strength of this that the species is mentioned here.

Habits.—Nothing is known of the habits of the hakeling except that it is a deep-water fish, having been taken from 79 down to 955 fathoms, where, to judge from its general structure, it lives on or near bottom.[26a]

160. **Four-bearded rockling** (*Enchelyopus cimbrius* Linnæus)

ROCKLING

Jordan and Evermann, 1896–1900, p. 2560.

Description.—The rocklings, of which this is the only common local representative, differ from their near relatives, the hakes (Urophycis), in the facts that the ventrals are short, with 5 to 7 rays, and that the first section of the dorsal fin consists of only one ray, which is nearly as long as the head and stands over the upper corner of the gill opening, followed by a series of about 50 very short, separate, hairlike rays without connecting membrane, which are depressible in a groove on the back. Thus there is only one well-developed dorsal fin. Rocklings differ further from all other gadoids in the presence of long barbels on the top of the nose as well as on the chin, the number of these being the most obvious specific character among the several species. In the present species there are a pair of these barbels close in front of the nostrils, a third and somewhat shorter barbel standing alone at the tip of the snout, and a fourth hanging from the chin.

Rocklings suggest young hake in their slender form, which tapers back from the shoulders, and, hakelike, they are rounded in front of the vent and compressed behind it. The upper jaw is longer than the lower and the teeth are small, but their noses are shorter and blunter, their eyes smaller, and the dorsal profile of their heads is more rounded than in any of the hakes. The pectorals are rounded, the narrow pointed ventrals being situated well in front of the latter. The second dorsal (45 to 53 rays) originates over the mid-length of the pectoral, runs back nearly to the base of the caudal, and is about equally high from end to end with rounded rear corner. The anal is similar to the second dorsal in form, though it is shorter (39 to 43 rays [27]). The caudal is oval when spread.

Color.—By all accounts, corroborated by our own experience, the color of this rockling is comparatively constant. Its back is dark yellowish olive or dusky brown, its sides paler, and its belly white dotted with brown. Sometimes the sides behind the vent are more or less clouded with a darker shade of the general body hue. The first dorsal ray, the posterior margins of the second dorsal and the anal, the lower half of the caudal, and the whole of the pectorals are sooty or bluish black. Otherwise the vertical fins are grayish or bluish brown. The ventrals are pale and the lining of the mouth dark purplish or bluish.

[26a] Another small hakelike fish (*Lotella maxillaris*) has been taken in 396 fathoms off Marthas Vineyard. It is separable from the hakeling described above by the fact that its anal fin originates behind the origin of the second dorsal, and by its larger teeth.

[27] Storer credits it with 48 rays, but subsequent students have not found so many.

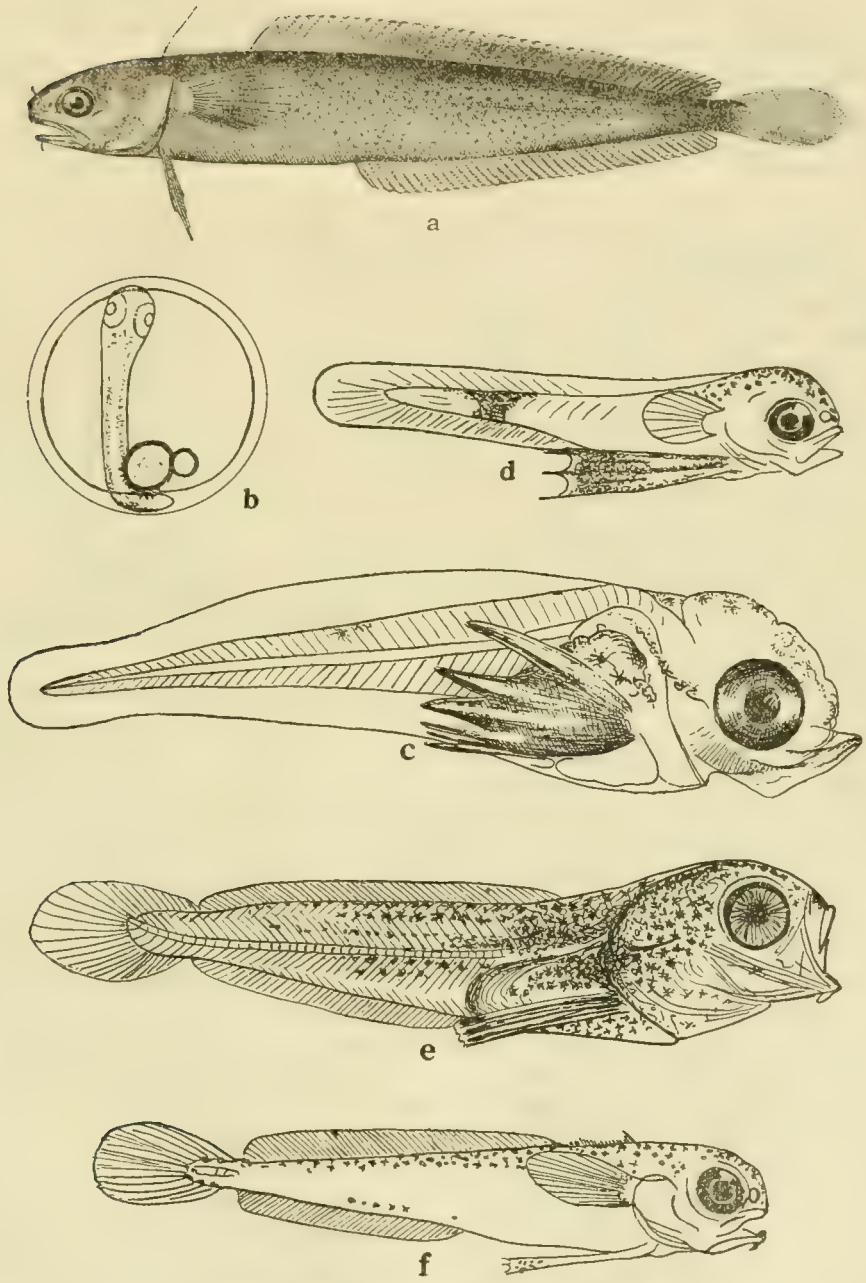

FIG. 229.—Four-bearded rockling (*Enchelyopus cimbrius*)

a, Adult. *b*, Egg (European). After Ehrenbaum and Strodtmann. *c*, Larva (European), 3.6 millimeters. After Ehrenbaum and Strodtmann. *d*, Larva (European), 5.3 millimeters. After Brook. *e*, Larva (European), 13.6 millimeters. After Ehrenbaum. *f*, Larva (European), 17.5 millimeters. After Brook.

Size.—This rockling has been known to reach a length of 16½ inches in Scandinavian waters but none so large has ever been reported in the Gulf of Maine, where they average only about 6 to 10 inches long.

General range.—Both sides of the North Atlantic. Its American range is from the Gulf of St. Lawrence (perhaps even further north) to Narragansett Bay in coast waters, and to the latitude of Cape Fear (N. C.) in deep water along the continental slope.

Occurrence in the Gulf of Maine.—The little rockling is of no commercial value and seldom comes up into very shallow water where it would force itself on the notice of seaside visitors, but it is a common bottom fish in the deeper parts of Massachusetts Bay as Goode and Bean (1879, p. 9) long ago remarked, while our experience, corroborated by Huntsman for the Bay of Fundy, is that this applies to the entire Gulf. Though it is nowhere abundant in the sense in which this term applies to cod, haddock, or hake, it is plentiful enough for its young to occur rather frequently in our tows in season (p. 461). The definite Gulf of Maine records for the adult are from St. Mary Bay (Nova Scotia), from various localities in the Bay of Fundy including Passamaquoddy Bay, from Jonesport, off Pemaquid, near Seguin Island, mouth of Casco Bay, Ipswich Bay, Gloucester, Nahant Beach, Provincetown, and various stations in the deeper parts of Massachusetts Bay. West of Cape Cod it becomes uncommon. It has been reported at least once on Georges Bank, and the *Albatross* trawled it on the slope off Nova Scotia and the *Fish Hawk* off Marthas Vineyard.

Rockling are bottom fish like hake, usually keeping to moderately deep water. For instance, we have trawled it in 25 to 33 fathoms from the *Grampus*, and it is most often found at considerable depths in the Bay of Fundy. Occasionally, however, rocklings have been taken in shallow water, as on Nahant Beach, for example; likewise in 6 fathoms in St. Mary Bay, in 7 fathoms in Buzzards Bay, and in water only a few feet deep at Woods Hole. On the other hand, rocklings have not yet been found in the deep basin of the Gulf of Maine, but their presence on the continental slope down to 300 fathoms [28] as well as in the deep gully off Halifax and in the channels of the Gulf of St. Lawrence [29] is proof that depth is no barrier to their populating the deepest parts of the Gulf of Maine if the surroundings are suitable in other respects. The deepest recorded capture is from 724 fathoms south of Cape Cod. This species is a year-round resident, except that rocklings may move inshore and into shoal water in autumn and offshore again and deeper in spring to account for the occasional appearance of adult rockling in very shallow water at Woods Hole in winter.[30]

The name "rockling" is a misnomer, for it is not a rock fish, being found chiefly on soft bottom in the Bay of Fundy, while those that we have trawled in Massachusetts and Ipswich Bays from the *Grampus* were on smooth muddy sand between the hard patches. Of course any rockling living in the deep sinks and gullies or on the continental slope are necessarily on soft smooth ground, not on

[28] Goode and Bean (1896, p. 384) list the deep-water records.

[29] Information supplied by Doctor Huntsman and Huntsman, 1918a, p. 63.

[30] Sumner, Osborne, and Cole, 1913,p 771.

rocky ground. There is no reason to suppose that the adult fish ever rise far above the bottom except by accident.

Food and habits.—Judging from the stomach contents of Scandinavian and British fish (none have been examined on this side of the water) they feed chiefly on shrimps, prawns, isopods, and other small crustaceans, less often on fish fry. On the other hand, rockling have themselves been found in cod stomachs in Massachusetts Bay, and no doubt haddock (all fish of prey, for that matter) devour them.

Rockling, like other gadoids, swim at the surface for their first few months, and we have taken their pelagic fry in our tow nets at the various localities marked on the accompanying chart (fig. 223) from the first week in July until October; seldom, however, more than half a dozen in any one haul (the largest catch was 18 specimens). Huntsman similarly describes them as common in the center of the Bay of Fundy and they have been taken in the tow at Woods Hole in April. How long they remain on the surface is not known, but analogy with cod, haddock, etc., suggests three months at most, and since our largest pelagic fry were 40 to 45 mm. long it may be assumed they seek the bottom at a length of about 2 inches. During this pelagic stage they drift with the current like other fish fry, and are at the mercy of mackerel and other fish, but they are not plentiful enough in the Gulf of Maine to be as important an article in the diet of the mackerel as are the fry of the far commoner European rocklings on the other side of the Atlantic.

Breeding habits.—Huntsman(1922a) found the eggs of this rockling in Passamaquoddy Bay in midsummer. Its breeding season probably endures from spring to early autumn in the western Atlantic as it does in the eastern Atlantic,[31] for Dannevig (1919) records rockling eggs (probably this species) as early as the end of May near Halifax, while on the other hand we have towed larvæ only 5.5 mm. long as late as September and October in Massachusetts Bay. Probably it spawns all around the peripheral belt of the Gulf, with Massachusetts Bay an important nursery, judging from our repeated capture of its larvæ there; but our failure to find rockling larvæ or its pelagic fry in the central part of the Gulf, or its eggs in any of our offshore tows, justifies the conclusion that its breeding is limited to depths less than 75 fathoms so far as the inner part of the Gulf of Maine is concerned, though it may spawn much deeper on the continental slope.

The eggs are buoyant, described (we have never seen them) as 0.66 to 0.98 mm. in diameter. When newly spawned the oil is in small droplets, most of which soon coalesce into one globule of 0.14 to 0.25 mm., often with one or two smaller ones close to it. The danger of confusing them with squirrel-hake eggs is discussed in the account of the latter species (p. 453). Newly hatched larvæ are slightly more than 2 mm. long. The yolk is absorbed at about 3.6 mm. and the later larval stages, up to about 10 mm. long, are characterized by the very large black ventral fins shown in the illustrations (fig. 239c), by the presence of *one* post anal band of black pigment, and by the short stocky body form. Young hake are more slender and have scattered pigment, young cusk have *two* post anal bands, and all other Gulf of Maine gadoids

[31] It spawns from the end of January until August in the Baltic.

have short ventral fins.[32] After the rockling is 17 to 20 mm. long the structure of its first dorsal fin serves to identify it. These larger fry are silvery, probably awaiting their descent to bottom before assuming the dull colors of the adult.

161. Cusk (*Brosmius brosme* Müller)

Jordan and Evermann, 1896–1900, p. 2561.

Description.—The cusk is separable from all its Gulf of Maine relatives at a glance by the fact that it has but *one* dorsal fin. The relationship of the anal and dorsal fins to the caudal and the outline of the latter are also characteristic, all three being continuous at the base but separated by notches so deep that they are obviously distinct, and with the caudal evenly rounded. The cusk is more slender than a hake, being only about one-fifth to one-sixth as deep as long, round-bodied in front, compressed behind the vent, and tapering evenly backward to the base of the caudal fin. The mouth is large, gaping past the eye and set slightly oblique, with small, sharp, curved teeth. The snout is blunt at the tip. The upper jaw incloses the lower when the mouth is closed, the eye is of moderate size, the chin bears a barbel, and the entire head and trunk are clad with small scales. The dorsal fin (85 to 105 rays) runs the whole length of the back from the nape and is of uniform and moderate height from end to end with rounded corners. The anal is similar to it in outline but only slightly more than half as long (71 to 76 rays). The pectorals are rounded and about half as long as the head. The ventrals are about as long as the pectorals, with their 5 rays free at the tips, and are situated slightly but obviously in front of the pectorals. All the fins are so thick and fleshy at their bases that it is only near the margins that the rays are apparent.

Color.—The cusk varies in color, no doubt conforming to the bottoms on which it lives. The upper parts range from dark slaty to dull reddish brown or pale yellowish, paling to grayish on the lower sides and to dirty white on the belly. Old fish are plain colored; in small ones, however, the sides are often barred transversely with about half a dozen yellowish bands. The pectorals and ventrals are of the same color as the sides and the ventrals are sooty at their tips. The most characteristic color mark is that all three vertical fins—dorsal, caudal, and ventral—which are of the general body tint at their bases, are black at the margin and narrowly edged with white.

Size.—Cusk grow to a maximum length of 3 feet and to a weight, it is said, of 30 pounds, but those caught in the Gulf of Maine average only 1½ to 2½ feet long and from 5 to 10 pounds in weight.

General range.—Both sides of the North Atlantic, chiefly in moderately deep water, north to the Newfoundland Banks, Gulf of St. Lawrence, Labrador, and Greenland; south regularly to Cape Cod and the South Channel, rarely to southern New England, and occasionally to New Jersey on the American coast.

[32] The Arctic three-bearded rockling (*Gaidropsarus argentatus* Rheinhardt) was reported from Massachusetts Bay by Gill (1864a, p. 241), who speaks of a specimen from Nahant; also by Storer (1867), who writes that many were picked up on Nahant Beach during one tide in the summer of 1860. Three more were found in the surf at West Beach, Beverly. All these specimens, however, were the young silvery fry. As it was not known at the time that the common rockling passed through such a stage, and since neither Gill nor Storer noted the number of barbels, it is more likely that they belonged to the four-bearded species than to the Arctic species. Should the latter prove to be a denizen of the Gulf the number of its snout barbels (p. 385) would serve for its identification.

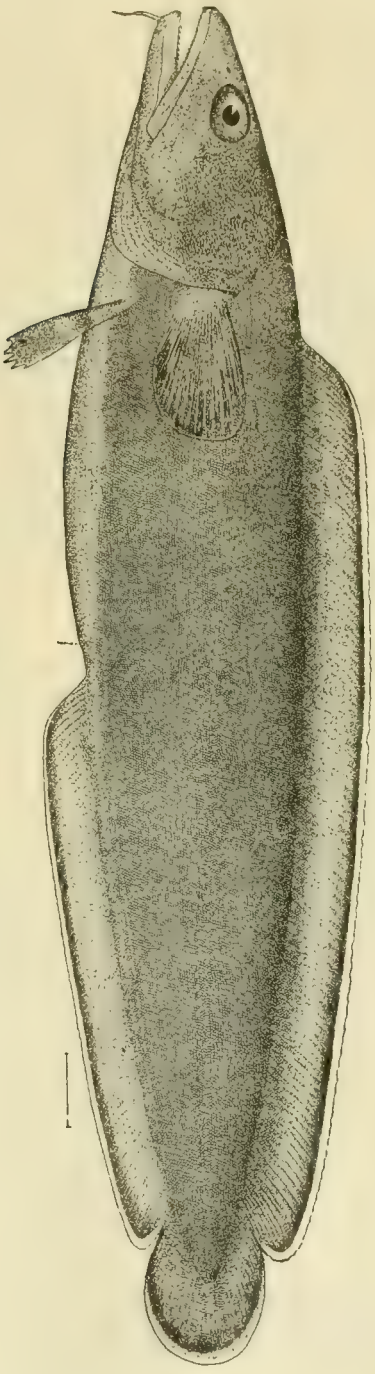

FIG. 230.—Adult

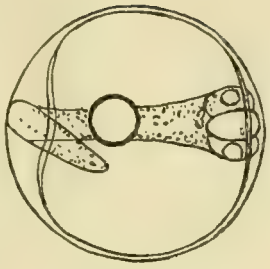

FIG. 231.—Egg (European). After Ehrenbaum.

FIG. 232.—Larva (European), 6.8 millimeters. After Schmidt

CUSK (*Brosmius brosme*)

Occurrence in the Gulf of Maine.—The cusk is generally distributed in the Gulf in water deeper than 10 to 15 fathoms, its presence or absence depending on the precise type of bottom. It is seldom caught on smooth sand but chiefly where the bottom is rough with masses of rocks, bowlders, or ledges, on gravelly and pebbly ground, and occasionally on mud with hake. The actual area occupied by this fish is but a fraction of that inhabited by cod, haddock, or pollock, and it varies greatly in abundance in different parts of the Gulf. Thus cusk are hardly ever caught in Cape Cod Bay but are plentiful off Cape Ann and on Jeffreys Ledge, the latter being one of the most productive grounds to be found anywhere in the Gulf of Maine. The rocky slopes of Cashes Ledge have long been famous for cusk, and in past years when more fishing was done there (in 1902 and 1905, for example) this ground was the chief source of supply of the cusk landed in New England. Large catches are also made among the rocks of Browns Bank and fair numbers are taken on the rockier spots on Georges Bank, though its smoother expanses yield only odd cusk. As might be expected cusk are caught on Fippenies and Platts Banks by the few vessels that visit those localities, and they are said to be plentiful on the rather indefinite ground off Penobscot Bay known as Jeffreys Bank (not Ledge), or "Matinicus sou'-sou'west." The following figures show the number of pounds of cusk landed at Boston and Gloucester, Mass., and Portland, Me., from the several offshore grounds in 1921:[33]

Browns Bank	440, 481
Georges Bank	182, 960
South Channel	177, 472
Stellwagen Bank	94, 455
Jeffreys Ledge	319, 143
Platts Bank	134, 166
Jeffreys Bank	43, 545

Many cusk, in the aggregate, are taken on various small inshore grounds, notably on the ledges off Chatham, on the broken grounds that extend from Cape Ann to Stellwagen Bank, and on the small rocky patches that skirt the coast of Maine, as appears from the catches made by small-boat fishermen in 1919 in the following Maine counties: York, 9,000; Cumberland, 79,116; Sagadahoc, 14,720; Lincoln, 26,664; Knox, 51,620; Hancock, 11,956; and Washington, 4,009.

Some cusk are also caught at the mouth of the Bay of Fundy, particularly about Grand Manan and off Brier Island, as Doctor Huntsman informs us, while small rocky patches along the west Nova Scotian shore and off Seal Island also yield cusk, though we can not state the catch as cusk are not listed as such in the Canadian fishery returns. They are taken regularly on Grand Manan Bank. German Bank and the fishing grounds off Lurcher Shoal are less favorable, consisting mostly of patches of gravel and pebbles and small stones alternating with sand and clay. The only important exceptions to the rule that cusk prefer rocky ground in the Gulf of Maine is that they are plentiful in the South Channel where the bottom is mostly smooth and sandy, and that a considerable number are caught with hake off the coast of Maine on broken or even muddy bottom. In Norwegian waters they

[33] Very little fishing was done on Cashes Ledge that year.

lurk among Gorgonian corals, and they may have the same habit on those parts of the offshore banks where these are plentiful. The annual landings of cusk in New England ports (which comprise the bulk of the Gulf of Maine catch) have ranged from 2 to more that 7 million pounds of late years.

The cusk is so purely an offshore fish that it is a rare occurrence for one to be caught in any harbor or estuary. For that matter, we have never heard of one taken in less than 10 to 15 fathoms of water. On the other hand it is safe to say that there are few if any cusk living below 100 fathoms or so in the deep basin of the Gulf, but this is because of the soft sticky bottom and perhaps scarcity of food, and not because of the depth, for they have been caught down to 500 fathoms in European seas. Neither are cusk to be found regularly on the continental slope, probably for the same reason, though Goode and Bean (1896, p. 385) place their lower limit off the New England coast at 250 to 300 fathoms.

Cusk are caught chiefly on hook and line. No doubt they spend their time mostly in hiding, but gill nets and otter trawls occasionally pick up a few. They are more or less solitary fish, nowhere as abundant as cod, haddock, or hake, as is illustrated by the following catches counted by representatives of the bureau in 1913 as they came from the water: Twenty miles east of Cape Cod Light, November 16 and 17, 1913, line trawl, 460 cusk to 2,150 haddock and 1,228 cod; 15 miles southeast of Monhegan Island, June 24 and 25, 1913, long lines, 580 cusk to 2,880 hake; Jeffreys Ledge, December 11 and 12, 1913, line trawl, 230 cusk to 470 haddock and 475 cod; northwest part of Georges Bank, October 10 to 13, 1913, otter trawl, 4 cusk and 12,473 haddock; 6 miles east of Boon Island, March 30, 1913, gill net, 5 cusk, 1,055 haddock, 51 cod, 20 pollock, and 76 plaice. It also seems that cusk are more stationary than most gadoids and move little from bank to bank for "Massachusetts fishermen tell me," writes Goode (et al., 1884, p. 233), "that these fish are usually found in considerable abundance on newly discovered ledges, and that great numbers may be taken for a year or two, but that they are soon all caught. Sometimes, after a lapse of years, they may be found again abundant on a recently deserted ground.[34]" Nor is there any definite evidence that the cusk performs an in or off shore migration with the seasons.

Cusk are so strictly bottom fish that we have never heard of one of any size swimming up into the upper waters. They are sluggish and weak swimmers, but they are powerful of body and when hooked they coil about the line in a troublesome way. Nothing is known of the rate of growth of the cusk.

Food.—Little is known of the diet of the cusk. European students describe the stomachs as usually containing crustaceans and sometimes mollusks. The cusk is not at all fastidious as to bait, accepting clams, cockles, and herring equally. So far as we can learn no record had been made of its stomach contents on this side of the Atlantic until W. C. Schroeder, of the Bureau of Fisheries, found crabs and occasional mollusks in several taken on Platts Bank in the summer of 1924.

Breeding habits.—What is known of the breeding habits, eggs, and larvæ of the cusk is due to European students. This fish spawns in spring and early summer [35] on both sides of the Atlantic. In European waters the season lasts

[34] In Vineyard Sound, according to Smith, the cusk was once not uncommon, but it has been a rare fish there for many years.
[35] Welsh saw fish nearly but not quite ripe near the Isles of Shoals in April and May.

from April until June, and probably it lasts all summer in the Gulf of Maine, for Mr. Schroeder reports a female on Platts Bank nearly ripe on July 23. In the eastern Atlantic cusk spawn chiefly below 100 fathoms, judging from the distribution of the eggs on the surface, but the chief production of eggs probably takes place in water shallower than this in the Gulf of Maine, where most of the stock lives in depths of less than 75 fathoms, and some must spawn close inshore, for we have towed the larvæ, only 6 to 13.8 mm. long, in Provincetown Harbor, off Cape Cod, and near the Isles of Shoals,[36] but we have never detected cusk eggs in our tows or seen perfectly ripe fish. The cusk is among the most prolific of fish, more than 2,000,000 eggs having been counted in a female of medium size. The egg is buoyant like that of other gadoids, 1.29 to 1.51 mm. in diameter, with one oil globule of

FIG. 233.—Larva (European), 12.5 millimeters. After Schmidt

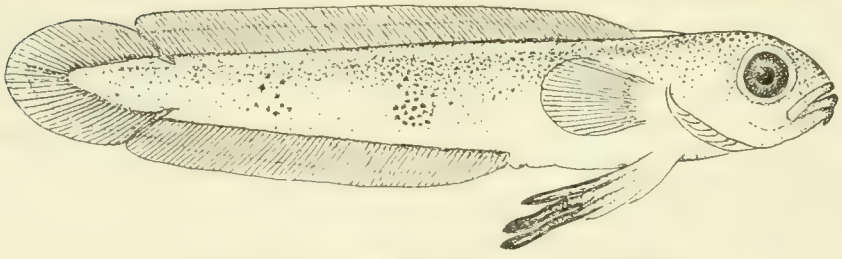

FIG. 234.—Fry (European), 42.5 millimeters. After Schmidt

CUSK (*Brosmius brosme*)

0.23 to 0.3 mm., and it may be recognized by the brownish or pinkish color of the latter and by the fact that the entire surface of the egg is finely pitted.

The larvæ are about 4 mm. long at hatching, with the vent situated at the base of the ventral finfold as in other gadoids, but they are separable from all other gadoid larvæ occurring in the Gulf of Maine by the pinkish oil globule at the posterior end of the yolk. The latter is absorbed in about a week after hatching, at a length of about 5 mm., and as the little cusk grows its ventral fins elongate like those of young hake and young rockling and become heavily pigmented with black. It is separable from both of these, however, by the fact that the ventral rays are independent and by the presence of three black patches—one on top of the head, a second over the gut, and a third at the tip of the tail—and two vertical black bands which divide the trunk behind the head into three nearly equal sections.

[36] The station records are 10012, July 22, 1912, 1 specimen; 10343, July 20, 1916, 4 specimens; and 10344, July 22, 1916, 1 specimen.

In the rockling there is only one band of pigment behind the vent, and no definite band in either of the hakes common in the Gulf of Maine. The first traces of the vertical fin rays of the young cusk are visible at about 12.5 mm., and the dorsal and anal fins are differentiated at about 28 mm., at which stage the ventrals are relatively at their longest. Fry of 40 mm. and upward show most of the characters of the adult, the relationship of the dorsal and anal fins to the caudal and the presence of only a single dorsal and anal fin being sufficient to identify them as such from this size on.

The older cusk fry, while still living at the surface, are described by Schmidt [37] as greenish yellow with blue eyes, *not* silvery-sided like young rockling and hake.

The young cusk lives near the surface like other gadoids until it is 2 inches or more long, and there is reason to believe that in European seas they first seek the bottom in considerable depths, but we have nothing to offer on this point for the Gulf of Maine.

Commercial importance.—The cusk is an excellent food fish and there is a ready market for all that are caught.

THE GRENADIERS. FAMILY MACROURIDÆ

The grenadiers are characterized externally by large heads, projecting snouts, and slender bodies tapering to whiplike tails with no definitely demarked caudal fin. There are two dorsal fins—the first high and the second very low, but occupying the greater part of the back—and there is an even longer anal. The grenadiers are now universally located close to the cod family in classification because of the structure of their skulls, but unlike that tribe there is one stout spine in the first dorsal fin. They are deep-sea fishes, living on the bottom, loose in texture and weak swimmers. Many species are known, but only three have ever been taken within the confines of the Gulf of Maine.

Besides the species described below, three others—*Coryphænoides rupestris*, *C. carapinus*, and *Hymenocephalus goodei*—have been taken sufficiently often on the continental slope abreast of the Gulf and off southern New England to show that they are not uncommon below 500 fathoms, but they are all typical inhabitants of the deep-sea floor and never likely to rise into shoal enough water to come within the limits of the Gulf of Maine.[38]

KEY TO GULF OF MAINE GRENADIERS

1. Dorsal spine perfectly smooth; snout projects considerably beyond the mouth----------Long-nosed grenadier (*Cœlorhynchus carminatus*), p. 471
   Dorsal spine serrated with teeth which can be felt if not seen; snout projects only slightly beyond the mouth---------- 2
2. Dorsal spine strongly serrated----------Common grenadier (*Macrourus bairdii*), p. 468
   Serrations on dorsal spine so fine as to be hardly visible----------Smooth-spined grenadier (*M. berglax*), p. 470

[37] Meddelelser fra Kommissionen for Havundersøgelser, Serie: Fiskeri, Bind I, No. 8, 1905, p. 7. He also describes the larval stages of the cusk.

[38] For descriptions of these and lists of the localities at which they have been taken see Goode and Bean (1896).

162. Common grenadier (*Macrourus bairdii* Goode and Bean)

RAT-TAIL; MARLIN-SPIKE

Jordan and Evermann, 1896–1900, p. 2583.

Description.—The grenadier once seen could hardly be mistaken for any other fish except one of its own tribe, so characteristic are its slender body (compressed behind the vent and tapering to a whiplike tail with no definite caudal fin) in combination with a pointed snout overhanging the mouth, very large eyes, and high first dorsal but very low second dorsal fin. It has a chin barbel like a cod (not shown in the illustration). As noted above, the second ray of the first dorsal fin is a true spine, serrated along its front edge with about 15 sharp and very noticeable teeth pointing upward. The first dorsal fin (2 stiff spiny rays and 11 softer rays) is triangular, about twice as high as long, its first ray very short, and originates over the pectorals close behind the gill opening. The space between the two dorsal fins is about as long as the height of the first fin. The second dorsal (about 137 rays) extends back to the tip of the tail, is so low that its membrane is hardly visible, and tapers to practically nothing at its rear end. The anal is considerably longer than the second dorsal (only about 120 rays, however) and more than twice as high. The pectorals are of ordinary form, rounded at the tip. The ventrals, which stand under or slightly behind them, are triangular with the first ray prolonged as a threadlike filament. The scales are rough with small spines. The jaws are armed with several bands of small recurved teeth.

Color.—Described as light brownish gray above, silvery below, with bluish belly, the lower surface of the snout pink, the throat deep violet, the first dorsal pink with blackish spines, and the eyes dark blue.

Size.—Usually about 1 foot long.

General range and occurrence in the Gulf of Maine.—This is normally a deep-water fish which has been found at many localities along the continental slope from the West Indies north nearly to the Grand Banks of Newfoundland, and rarely in the Gulf of St. Lawrence. It is also known from the mouth of the Laurentian Channel, on the Scotian Banks, in the Gulf of Maine, and even in Vineyard Sound. Grenadiers usually live in at least 80 to 90 fathoms of water and thence down to 1,000 to 1,200 fathoms (deepest record 1,255 fathoms); but one was trawled in 9 fathoms in Vineyard Sound by the *Fish Hawk* many years ago, a second was found floating near the surface at Eastport by Dr. W. C. Kendall, and a third was taken in a weir at Lubec, as reported by Huntsman. The only other records of grenadiers within the Gulf of Maine are of one caught in 160 fathoms in the Western Basin, 44 miles off Cape Ann, and another taken off Gloucester, both taken many years ago. They may be more common on the soft muddy bottoms of the deep basins of the Gulf in 100 to 125 fathoms than this would suggest, overlooked, perhaps, because few fishermen ever set their trawls on these grounds, which are not productive either of cod or of haddock. Grenadiers, together with the long-finned hake (p. 456), are the most abundant fish[39] on the continental slope off the Gulf below 100 fathoms.

[39] For a list of captures on the continental slope see Goode and Bean (1896, p. 394).

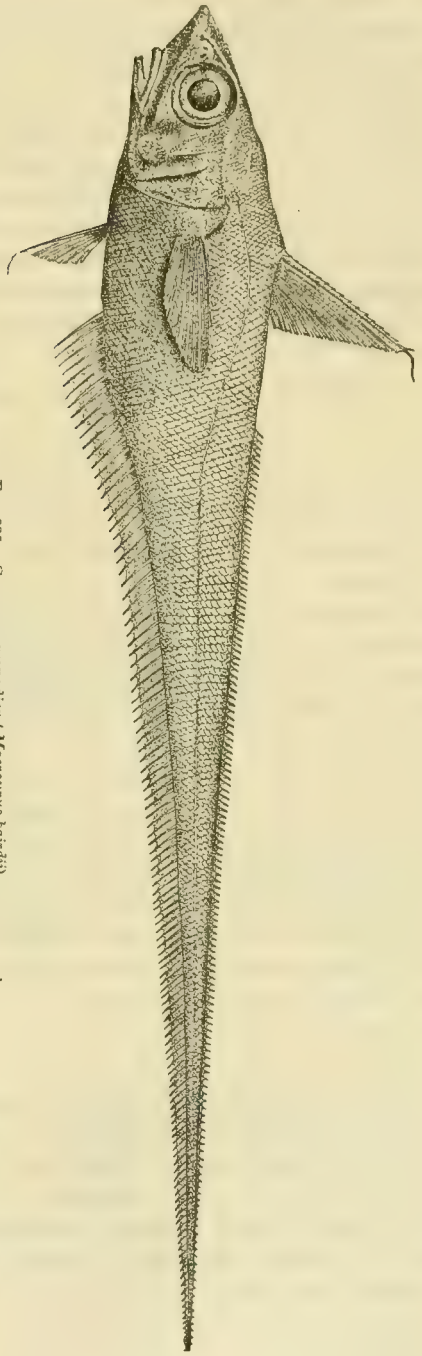

FIG. 235.—Common grenadier (*Macrourus bairdii*)

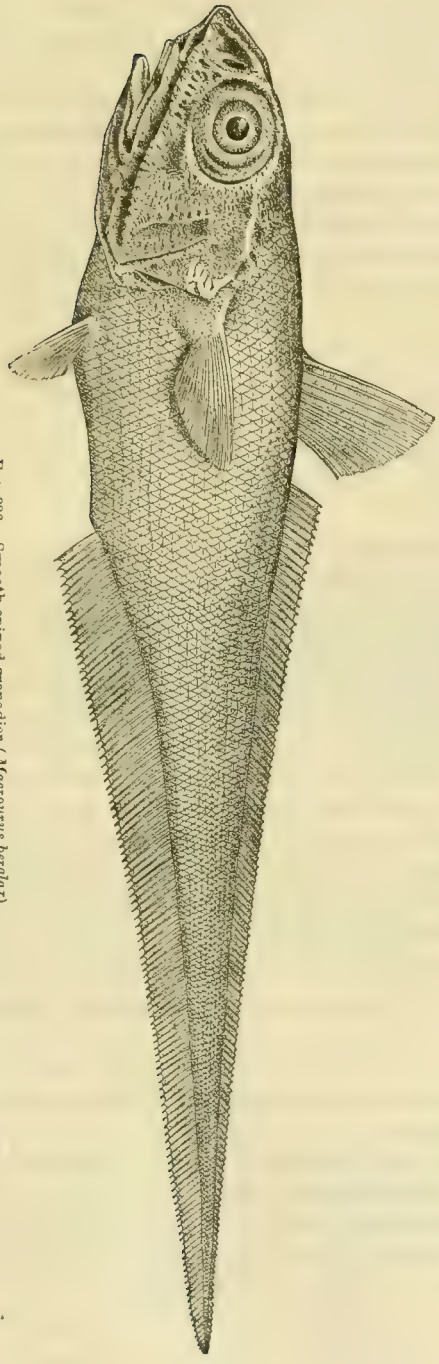

FIG. 236.—Smooth-spined grenadier (*Macrourus berglax*)

Habits.—Little is known of the habits of the grenadier except that it is a bottom fish, usually found on soft mud, and a very feeble swimmer, while Hensen's [40] report of pelagic euphausiid shrimps (*Thysanoessa longicaudata*) in a grenadier stomach is the only observation which has so far been made on its diet.

Probably grenadiers spawn in summer and autumn, for the spermaries of the specimen from the western basin of the Gulf, just mentioned, were nearly ripe on August 19, but neither the eggs, larvæ, nor young fry of this fish have been seen. The former, however, probably resemble other macrurid eggs described by European authors;[41] that is, they are buoyant at least for the first part of incubation, with a large oil globule, wide perivitelline space, and sculptured on the surface into concave hexagonal facets. Larval macrurids of other species have the rays of the first dorsal and ventral fins much elongated.

163. **Smooth-spined grenadier** (*Macrourus berglax* Lacépède)

RAT-TAIL; ONION-EYE

Jordan and Evermann, 1896–1900, p. 2581.

Description.—This species so closely resembles the common grenadier (p. 468) in its general appearance that we need only point out the points of difference. Most obvious of these are that its snout is shorter and blunter, with more highly arched dorsal profile; that there are from 4 to 6 distinct ridges on the top of the head; that the trunk is relatively stouter (about 6 or 7 times as deep as long); and that the serrations of the second ray of the first dorsal fin are so much finer as to be hardly visible. Furthermore there are fewer (about 124) rays in the second dorsal fin, more (about 148) in the anal, and the first dorsal is of rather different outline than in the common grenadier. The second dorsal is relatively higher and with its membrane more developed (compare fig. 236 with fig. 235), while none of the authors who have described this grenadier (we have never seen it) have mentioned any filamentous prolongation of the ventral fin such as occurs in *Macrourus bairdii*. The structure of the scales is also diagnostic, though visible only under a lens, for those on the body of the present species are described as armed with one median or with two lateral ridges of spines whereas in *M. bairdii* there are 10 to 12 rows of spines on each scale.

Color.—No information is available as to the color of this fish in life.

Size.—Larger than the other grenadier (p. 468), being credited with a maximum length of 3 feet and a weight of 4 or 5 pounds.

General range and occurrence in the Gulf of Maine.—This is a deep-water fish like its relative but more northerly in its distribution, being known off northern Norway, Spitzbergen, Iceland, southern Greenland, in Davis Strait, and southward along the continental slope of North America as far as Georges Bank. One has even been found dead, floating on the surface, off New York Harbor.

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[40] Proceedings, U. S. National Museum, vol. 48, 1915, p. 99.

[41] Ehrenbaum (Nordisches Plankton, Band I, 1905–1909) summarizes what little is known of the eggs and young of this group of fishes.

Half a century ago when halibut were more plentiful in the Gulf of Maine than they are to-day, and when line trawlers from Gloucester still resorted regularly to the deep gully between Browns and Georges Banks, they frequently caught large grenadiers which probably were of this species, and likewise caught them in the deep gullies on the Scotian Bank farther to the eastward, as well as off its seaward slope. Fishermen even described them as common enough to be a nuisance, for they were of no commercial value and stole bait meant for better fish. It was on the strength of such reports that Goode (et al., 1884, p. 244) described it as "exceedingly abundant on all our offshore banks." During the early days of the Bureau of Fisheries a few were brought in by fishermen from "off the coast of New England,"[42] and no doubt fishermen still hook them as of old off La Have and Sable Island Banks. However, it is long since one has been reported from the Gulf of Maine, not because they are no longer to be caught but simply because less line trawl fishing is now done there in water deep enough. One hundred fathoms may be set as the usual upper limit for this grenadier, and most of those caught have been from 100 to 300 fathoms on both sides of the Atlantic, while it has been taken as deep as 677 fathoms by the *Albatross* off the southeast slope of Georges Bank. It

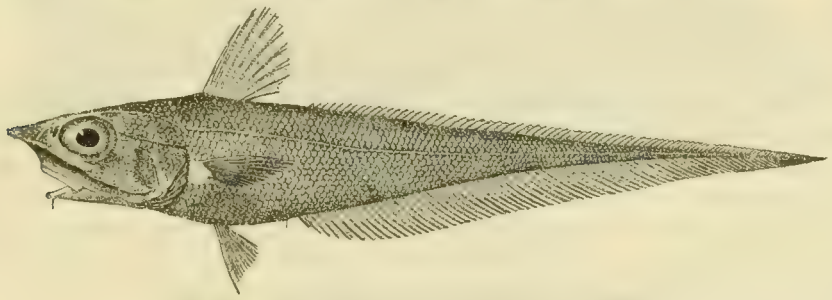

FIG. 237.—Long-nosed grenadier (*Cœlorhynchus carminatus*

is supposed to feed on small fish and on Crustacea but we find no definite record of the contents of its stomach. Females with the roe nearly ripe have been taken off northern Norway in May, suggesting that it is a spring spawner, but nothing more definite is known of its breeding habits.

164. **Long-nosed grenadier** (*Cœlorhynchus carminatus* Goode)

Jordan and Evermann, 1896–1900, p. 2588.

Description.—This species so closely resembles the common grenadier (p. 468) in general appearance that there is danger of mistaking it for the latter; but it is identifiable by the facts that its dorsal spine is perfectly smooth and its first dorsal fin rounded instead of acutely triangular, while the snout overhangs the mouth farther and is more pointed and flattened (commonly described as "sturgeonlike," but this characterization applies better to other members of the genus which have still longer snouts).

Color.—Described as silvery gray.

Size.—About 10 inches long.

[42] Bean, 1881, p. 80.

General range and occurrence in the Gulf of Maine.—This is a deep-water ground fish which has been taken at many localities off the American coast from the West Indies and Gulf of Mexico northward along the continental slope to abreast of southern New England in depths of 104 to 464 fathoms. It is included here because once recorded off Nantucket in 148 fathoms, but this is apparently about its eastern limit for it has not been reported from the slope of Georges Bank and hence is hardly to be expected in the Gulf of Maine proper.

THE FLOUNDERS AND SOLES. FAMILIES PLEURONECTIDÆ AND SOLEIDÆ

The flatfishes are a very homogenous tribe, so different from all other fishes that no one is apt to take one for any other fish. What strikes one first is their flatness; less obvious is the fact that they lie not on the belly but on one side, right or left; and the skull so twists in the course of development that the eye, which was originally on the side fated to be underneath, migrates around the head so that both eyes finally come to lie close together on the side that is uppermost as the fish lies. The mouth, however, more nearly retains its original position and hence is often described as opening sidewise. The larval flounder swims on edge like any other fish, the migration of the eye taking place just before the fry take to the bottom.

All flounders have a single long fin on each edge, one the dorsal and the other the anal, with well-developed ventrals. Most of the Gulf of Maine species also have large pectorals, one on the upper side as the fish lies on the bottom and the other on the lower side. The ventrals are in front of or in line with the pectorals, the abdominal cavity is very short, and some species are armed with a stout anal spine. The distinction between the two families is indefinite and bridged by several genera which are more or less intermediate between them. Most Gulf of Maine flatfish are typical flounders (Pleuronectidæ), the soles (Soleidæ) being represented there by the hog-choker (p. 522) alone.

Our several flatfishes look much alike. Indeed, they are often confused, but it is not difficult to tell one from another as the diagnostic characters are rather precise, if not obvious at first glance. Huntsman (1918c) has published a very useful key to the eastern Canadian species, which is expanded here to cover the Gulf of Maine.

KEY TO GULF OF MAINE FLATFISHES

1.	Eyes on the left side (guts at left edge as the fish lies)	2
	Eyes on the right side (guts at the right)	5
2.	Lateral line arched over the pectoral fin [43]	3
	Lateral line straight	*Citharichthys arctifrons*, p. 521
3.	The two ventral fins are alike	4
	The two ventrals are not alike, the left (upper) being continuous with the anal fin, the right (lower) separate from it	Sand flounder, p. 516
4.	Upper side with four large oblong black eye spots; less than 75 rays in the long (dorsal) fin	Four-spotted flounder, p. 494
	Upper side with many small spots; more than 85 dorsal fin rays	Summer flounder, p. 491
5.	There is a well-developed pectoral fin on the eyed side	6
	No pectoral fins	Hog-choker, p. 522

[43] In all the flounders of this type so far recorded from the Gulf of Maine both pectorals are well developed. Should one be taken with *no* pectoral fin on the blind side it would probably be the deep-water *Monolene sessilicauda* (p. 521).

6. Mouth large, gaping back as far as the eye; jaws and teeth nearly equally developed on both sides 7
Mouth small, not gaping back as far as the eye; the jaws nearly straight on the upper side and curved on the lower side 8
7. Tail slightly forked; lateral line arched just behind the gill opening ..... Halibut, p. 473
Tail slightly forked; lateral line nearly straight ..... Greenland halibut, p. 481
Tail rounded; lateral line nearly straight ..... American plaice, p. 482
8. Lower side of head with large open mucus pits; 100 or more rays in the long (dorsal) fin ..... Witch, p. 511
Lower side of head lacks open mucus pits; less than 90 dorsal fin rays 9
9. Lateral line arched behind the gill opening ..... Dab, p. 495
Lateral line nearly straight 10
10. Top of the head between the eyes rough with scales ..... Winter flounder (including also the Georges Bank flounder), p. 501
Top of the head between the eyes naked and smooth ..... Smooth flounder, p. 508

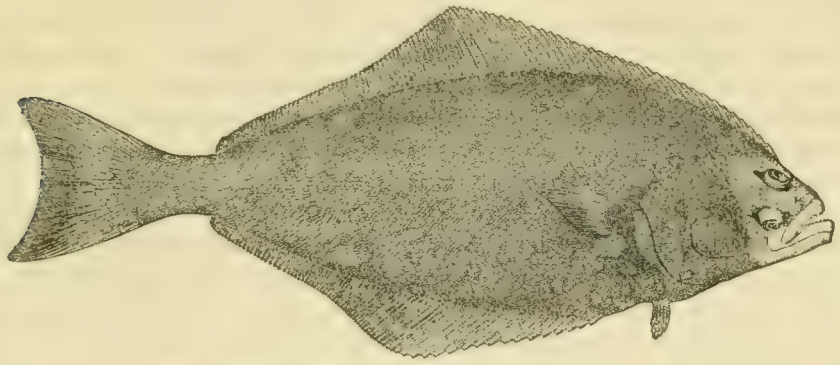

FIG. 238.—Halibut (*Hippoglossus hippoglossus*)

165. **Halibut** (*Hippoglossus hippoglossus* Linnæus)

Jordan and Evermann, 1896–1900, p. 2611.

Description.—This is not only the largest but one of the best characterized of flatfish, its most obvious diagnostic characters, apart from its size, being the facts that it lies on the left side;[44] its mouth is large, gapes back to the eyes, and is armed with sharp curved teeth; its tail is emarginate, not rounded; its two ventral fins are alike; and its lateral line is arched abreast of the pectoral fin. Furthermore it is a narrower fish, relatively, than most of our flounders (only about one-third as broad as long) but very thick, and its eyes are more widely separated than in most flounders. The dorsal (long) fin (98 to 105 rays) commences abreast of the eye and runs back the whole length of the fish, broadening but slightly for the first third of its length and then abruptly, to narrow again toward the caudal peduncle. The anal is similar in outline but shorter (73 to 79 rays), originates close behind the pectoral, and is preceded by a sharp spinelike projection of the post-abdominal bone, which projects in young fish but is hidden by the skin in old fish. The two pectoral fins are unlike, the one on the upper (eyed) side of the fish being obliquely pointed while the fin on the lower side is rounded. The rather small ventrals, which are situated before the pectorals and are separated from the anal by a

[44] Left-handed halibut have occasionally been caught.

considerable space, are alike. Halibut, like other flounders, are scaly on the whole head and body and are very slimy with mucus.

Color.—The halibut is chocolate to olive or slaty brown on the eyed (upper) side. Young fish are lighter and more or less mottled while large ones are more uniform and darker, sometimes almost black. The blind (lower) side is pure white in small fish, but large ones are often more or less blotched or clouded with gray (known by fishermen as "grays").[45]

Size.—Among Gulf of Maine fishes only swordfish, tuna, and some of the larger sharks reach a greater size than the halibut, and since the reports of specimens of 600 to 700 pounds have usually been looked on as exaggerations we are glad to be able to give at least one record of a Gulf of Maine halibut in this weight class. The fish in question was taken in June, 1917, by Capt. A. S. Ree, about 50 miles east-northeast of Cape Ann, and since it weighed 615 pounds (gutted, but with the head still attached) when brought in to the Boston fish pier it must have been as heavy as 700 pounds while alive.[46] Another halibut of 602 pounds is said to have been taken near Isle au Haut in 1902, but we can not vouch for this.

Halibut of 500 to 600 pounds are rumored almost every year, but the next largest of which we have definite knowledge was one of about 450 pounds caught on a hand line in the deep water between Browns and Georges Banks in 1908 by W. F. Clapp. Goode (et al., 1884) likewise had records of a dozen fish of 350 to 400 pounds caught off the New England coast, but a halibut heavier than 300 pounds is, and apparently always was, a rarity anywhere in the North Atlantic, so much so, indeed, that the heaviest ever caught or seen by two of the most experienced halibut fishermen who supplied Goode with information weighed only about 300 (237 dressed) and 401 pounds, respectively (the latter caught near Race Point, Cape Cod, in July, 1849). Full-grown females average about 100 to 150 pounds. Males run smaller, and most of the "large" fish landed in New England ports weigh from 50 to 200 pounds. Halibut between 7 and 8 feet long usually weigh 300 to 350 pounds, and the relationship of length to weight in the smaller sizes appears from the following table based on Icelandic fish measured by Jesperson.[47]

Length, in inches	Weight, in pounds
74	215
70	168
61	107
54 to 56	60½
40 to 42	29
36	11 to 12
30	9½
27	6½
24	5½

General range.—The halibut is a cold-water fish found in the North Pacific, the Arctic, and in the North Atlantic Oceans. They are, or once were, caught in abundance off the eastern coast of North America from the Gulf of St. Lawrence

[45] Storer (1867) says that halibut with both sides brown have been seen, and occasionally a fish with the lower side marked with dark patches of the same color as the upper side.

[46] An account of this fish was given in the Boston Daily Globe of June 12, 1917. It was purchased by the Shore Fish Co.

[47] Meddelelser fra Kommissionen for Havunders⌀gelser, Serie: Fiskeri, Bind V, Nr. 5, 1917.

and the Newfoundland Banks to the region of Nantucket Shoals, and occasionally as far south as New York. The Greenland side of Davis Strait likewise supports a productive halibut fishery, and they are caught well beyond the Arctic Circle along this coast. As there are no definite records of halibut from the east coast of Labrador north of the Straits of Belle Isle, however, it seems that they shun the icy Labrador current. Further evidence that halibut are not at home in truly Polar temperatures is afforded by the fact that while it is taken at Spitzbergen, about Bear Island, and off the Murman coast, it is not known on the Arctic coasts of Asia or of North America.

In the eastern side of the Atlantic the waters around Iceland and the Faroes are the seat of important fisheries, and halibut are regularly caught from northern Norway south to the Irish Sea, North Sea, and English Channel, while odd fish are even landed from the Bay of Biscay.

Occurrence in the Gulf of Maine.—The history of the halibut in the Gulf of Maine, like that of the salmon, must be written largely in the past tense for it is one of the species the stock of which has been seriously depleted there by overfishing. In Colonial days the halibut was a familiar and apparently very abundant fish on the northern New England coast but considered hardly fit for food. Wood (1634, p. 37), for instance, writes "the plenty of better fish makes these of little esteem, except the head and finnes, which stewed or baked is very good; these hollibuts be little set by while basse is in season." They seem to have maintained their numbers down to the first quarter of the nineteenth century, when, as contemporaries remark, halibut were extremely numerous in Massachusetts Bay and along Cape Cod, in fact around the whole coast line of the Gulf of Maine. They were discovered in abundance on Nantucket Shoals, on Georges Bank, on Browns Bank, and on the Seal Island ground as soon as fishing was regularly undertaken offshore. During the early years of the nineteenth century many were caught in Massachusetts Bay, particularly on Stellwagen Bank, and all along the eastern shore of Cape Cod, and in fact the cod fishermen of those days looked upon them as a nuisance and seldom worth bringing in to market. However, a demand for halibut arose in the Boston market sometime between 1820 and 1825 and ever since then they have been pursued relentlessly, first inshore and then farther and farther afield. During the early years of the fishery the Massachusetts Bay-Cape Cod region yielded large numbers of these great fish. For instance, four men are reported to have caught 400 in two days off Marblehead in 1837, a party of equal size is said to have landed 13,000 pounds off Cape Cod in three weeks, while it was discovered some time prior to 1840 that halibut congregated in winter in the 25 to 30 fathom gully between the tip of Cape Cod and Stellwagen Bank. However, a shrinkage in the supply had been noticed along shore even before 1839, for we find halibut described in that year (in the Gloucester Telegraph) as "formerly" caught along Cape Cod and Barnstable Bay, and they were so nearly caught out in the Massachusetts Bay region by about 1850 that it no longer paid even small boats to go out especially for them. Halibut held out better in the northeast corner of the Gulf where there was not as ready a market as in Boston. Perley, indeed, wrote of them as plentiful enough to be a

plague to the local fishermen off Brier Island as recently as 1852, but it was not long thereafter before their numbers there were greatly reduced.

The offshore fishery for halibut began about 1830, when the cod fishermen brought word to Gloucester of a great abundance of them on Georges Bank,[48] and for a few years thereafter they were caught there in numbers which to-day seem almost unbelievable. Thus we read of 250 caught in three hours, of vessels loaded in a couple of days, and of a single smack landing 20,000 pounds in a day. They were also taken in great plenty on Nantucket Shoals during this same period, but the supply seems to have dwindled suddenly in 1848 in the shoal waters both of Georges Bank and of the Shoals, and so permanently that few vessels went thither especially for halibut after 1850. Now forced to seek further afield, the fishing fleet found that halibut were plentiful on the Seal Island ground, on Browns Bank, and in the Eastern Channel or "gully" separating the latter from Georges Bank—localities which supplied the New York and Boston markets for the next decade. In 1875 halibut fishing was undertaken in deep water (100 to 200 fathoms) on the southeast slope of Georges Bank, but it was not long before all these grounds were fished out to the point where it was seldom possible to make paying trips to them for halibut alone. For many years now most of the halibut caught in the Gulf of Maine have been taken incidentally by cod, haddock, or hake fishermen, few vessels fitting for these great fish alone unless bound further afield.

Fortunately for the fishing industry the depletion of the Gulf of Maine was compensated for by the discovery of halibut in such abundance along the deeper slopes of the banks to the north and east that at first they seemed inexhaustible; and for many years now most of the halibut fishermen sailing from New England ports have resorted to the neighborhood of Sable Island Bank (fishing, however, in deep water), to the general region of the Grand Banks, to Greenland, or to Iceland.

Although there is not one halibut in the Gulf to-day, where there were hundreds in the first quarter of the nineteenth century, the geographical range of this noble fish is as extensive there as ever it was, odd halibut still being caught along Cape Cod, in Massachusetts Bay (where a good many "chickens" of 10 pounds and upward were brought in during the summer of 1922), all along the Maine coast, in the Bay of Fundy, and on all the offshore grounds. Thus we find small boats accounting for the following catches in 1919, following the coast line around from Cape Cod:

	Pounds
Massachusetts:	
Barnstable County	10, 211
Suffolk County	1, 449
Essex County	6, 081
Maine:	
York County	3, 050
Cumberland County	3, 844
Sagadahoc County	11, 040
Lincoln County	800
Knox County	22, 275
Hancock County	17, 380
Washington County	38, 165

[48] Goode and Collins (1887, p. 3) have collected data on the Georges Bank halibut fishery and the former abundance of the fish there.

Halibut are also caught fairly regularly about Grand Manan (15,500 pounds reported thence in 1919), but only occasionally about Campobello and near St. Andrews, and not at all along the north (New Brunswick) shore of the Bay of Fundy east of St. John. On the Nova Scotian side, however, small numbers occur right up to the head of the bay, and they are sufficiently numerous off Brier Island at its mouth and on the fishing grounds along western Nova Scotia to bring the landings for Digby County to 332,000 pounds in the year in question.

The largest catches of halibut now made within the limits of the Gulf of Maine come from the Cape Sable-Browns Bank ground, from the deeper slopes of the latter, from the gully between it and Georges Bank, and from the eastern part and slope of that bank. In 1919 the landings of halibut from these localities by Canadian and New England vessels combined amounted to slightly more than 2,000,000 pounds. A few fish are caught in the South Channel (117,471 pounds for 1919), but hardly any are now found on Nantucket Shoals, where they were once so plentiful.

The smaller banks within the Gulf likewise yield a few halibut still, the figures for 1919 being as follows: Fippenies, 3,564 pounds; Stellwagen, 5,793 pounds; Jeffreys Ledge, 12,733 pounds; Cashes, 3,564 pounds; and Platts, 16,921 pounds. With line trawlers [49] picking up a few halibut along Cape Cod (11. 752 pounds in 1919), the total yield of the Gulf of Maine came to nearly 3,000,000 pounds (something like 30,000 individual fish) for the year in question.

The relationship between the distribution of the halibut in the Gulf of Maine and the depth of the water which they chiefly inhabit has been altered within historic times by intensive fishing. At the present time this is usually classed as a rather deep-water fish, being most plentiful on the deeper slopes of the banks which it inhabits and in 100 to 300 fathoms of water in the gullies between them. This does not seem to have been the case in the early days of the local halibut fishery (not, at least, in the Gulf of Maine), for they were then common in but a few fathoms of water in Massachusetts Bay, many wintering in the gully between Stellwagen Bank and Cape Cod, which is only 25 to 30 fathoms deep, while the early fishing on Georges was on the shoaler parts of the bank in depths of 15 to 30 fathoms or even less. Not only did the first visitors to this ground describe the halibut as schooling at the surface in pursuit of herring and launce (not an uncommon event in the Gulf of St. Lawrence and off Newfoundland when they are chasing capelin), but the fish so often followed their hooked companions up to the top of the water that more than one vessel made a good part of her fare by gaffing them alongside. The Nantucket Shoals halibut of old were likewise in less than 30 fathoms depth, and when the fleet first repaired to Browns Bank and to the Seal Island grounds they found halibut very plentiful in water but little deeper. In fact, it was not until 1874 or 1875 that the presence of this fish was suspected in the deeper gullies or below 100 fathoms on the offshore slopes of the banks. It did not require many years of fishing to catch up most of the halibut living in very shallow water, and so thoroughly that although we hear of odd fish close inshore every year few are taken now in less than 30 to 40 fathoms and most of the catch is made much deeper than this.

[49] The otter trawlers that carried investigators from the Bureau of Fisheries in 1913 took halibut on more than half of their trips to Georges Bank, usually from 1 to 75 fish per trip.

The history of the halibut fishery leaves no doubt that this species shows the effect of hard fishing sooner than most sea fish, it being possible to catch up the majority of the stock on any limited area in a few years, and so thoroughly and constantly do the cod and haddock line trawlers search all the good fishing bottoms of the Gulf of Maine and its banks that halibut never have a chance to reestablish themselves in any abundance on the shoaler grounds. They maintain their numbers better on the deeper slopes chiefly because they are subject to less intensive persecution there, for it is only while and where halibut are plentiful enough to yield paying fares that vessels fish regularly in such localities.

The surface is the upper limit for the halibut, as we have just noted, while 300 to 350 fathoms may be set as the lower boundary to their existence in any numbers, but the absolute depth limit is not known. It is sufficiently established that on the whole large halibut keep to deeper water than small ones, a fact early noticed on Georges Bank where the fish taken on the shoaler bottoms were all small (125 to 180 pounds), much larger ones being caught on the deeper slope to the southeast, and this rule holds equally for the other side of the Atlantic. The halibut, like all flounders, is normally a bottom fish, although it comes to the surface on occasion (p. 477). It is usually found on sand, gravel, or clay, not on soft mud or on rock bottom.

Food.—The halibut is very voracious, preying chiefly on other fishes, a long list of which have been reported from halibut stomachs, among them being cod, cusk, haddock, rosefish, sculpins, grenadiers, silver hake, herring, launce, capelin, flounders of various sorts (these seem to be its main dependence), skates, wolffish, and mackerel. It is also known to eat crabs, lobsters, clams, and mussels. Even sea birds have been taken from halibut.[50] Fishermen have reported finding in halibut caught nearby, the heads and backbones of cod thrown overboard while dressing down, and a variety of indigestible objects such as pieces of wood or iron and even a fragment of drift ice. In any given locality the diet of the halibut depends on what other ground fish are most easily available. Thus they are reported to feed chiefly on flatfish on Georges Bank and on cod, haddock, cusk, and sculpins on other grounds. Halibut, like other flounders, must be nearly invisible as they lie on bottom, capturing their prey by a sudden rush after any fish that passes within reach. Due to their great size and activity they are very destructive to smaller fishes. We read, indeed, of half a bushel of flatfish taken from one halibut, and of old, when they were so plentiful on the shoaler banks, fishermen said the appearance of a school of halibut soon drove away the cod and haddock. The halibut in turn falls prey to seals and especially to the Greenland shark, for which it serves as a staple article of diet.

Habits.—Little is known of the movements of the halibut except that its young, like other flounder fry, swim near the surface for some months after hatching (how long is not known), to take to the bottom at a length of 4 to 5 inches. The older fish have often been credited with extensive journeys from bank to bank or from deep to shallow water and vice versa, and they certainly rove the bottom in

[50] Smitt (Scandinavian Fishes, 1892) speaks of a halibut that had eaten a razor-billed auk; Goode and Collins (1887) record an "ice bird" (probably a dovekie) taken from one caught on Georges Bank.

bands in search of food as haddock do; but the available evidence as to their migrations is so contradictory and so complicated by the local effects of hard fishing that it is not worth while to attempt any discussion of it here, except to point out that of old when halibut were still plentiful in the inner parts of the Gulf some of them worked inshore and into shoal water in summer, to descend again to greater depths for the winter, while others remained in deep water throughout the year.

The rate of growth of so large a fish is an interesting subject, and fortunately Jespersen's [51] study of the otoliths of over 2,000 fish of all sizes caught about Iceland has thrown considerable light upon it, his conclusions being that the average relationship between age and size is as follows:

Age	Average length	Extremes of length	Age	Average length	Extremes of length
	Inches	*Inches*		*Inches*	*Inches*
One year	3.9	3.1 to 5.9	Six years	25.6	20.9 to 34.3
Two years	9.1	7.1 to 12.6	Seven years	27.6	21.7 to 40.9
Three years	13	8.3 to 18.9	Eight years	29.1	22.8 to 40.6
Four years	18.5	11.8 to 24.4	Nine years	33.9	26.8 to 42.1
Five years	22.4	16.1 to 28	Ten years	37.4	29.5 to 55.5

Females averaged somewhat longer and heavier than males of the same age, and the fact that the oldest was a fish of 20 years, 68½ inches long, suggests that the monsters of 400 pounds and more, and upward of 7 feet long, which are occasionally caught, may be half a century old, always assuming about the same rate of growth for the Gulf of Maine halibut as for those caught about Iceland. Probably the halibut does not reach sexual maturity until 9 or 10 years old. According to Thompson (Report of the Commissioner of Fisheries, Province of British Columbia, 1914 (1915), pp. 76–99) Pacific halibut grow at approximately the same rate for the first few years, more slowly after about the eighth year, but with wide differences in the rate of growth on different banks, probably reflecting differences in the food supply.

Breeding habits.—Very little is known about the breeding habits or early life of the halibut. It is believed to spawn in February in European and Icelandic waters, judging from the state of development of the ovaries. Halibut continue breeding throughout the summer off the American coast, for fishermen have frequently reported ripe fish, both male and female, in April, May, June, July, August, and early September at various localities from Georges Bank to the Grand Banks;[52] while the fact that part of the eggs in the ovaries of a fish examined on Banquereau by representatives of the Bureau of Fisheries on September 13, 1878, were ripe while others were still immature is evidence that individual halibut spawn over a considerable period. The pelagic larval and post larval stages had been found only over great depths, a fact which has led European students generally to believe that the halibut spawns outside the 500-fathom line; but Cox (Contributions to Canadian Biology, New Series, Vol. I, No. 21, 1924, pp. 409–412) has recently

[51] Meddelelser fra Kommissionen for Havundersøgelser, Serie: Fiskeri, Bind V, No. 5, 1917.

[52] Goode (et al., 1884) mentions many reports to this effect.

reported two larval halibut, 20 and 21.5 mm. long, taken close in to the southern coast of Nova Scotia in shoal water, and fishermen's reports of ripe fish suggest that the slopes of all the offshore banks east of Cape Cod serve as spawning grounds. It does not necessarily follow, however, that all are suitable as nurseries. On the contrary halibut smaller than a couple of pounds or so are so extremely rare in the

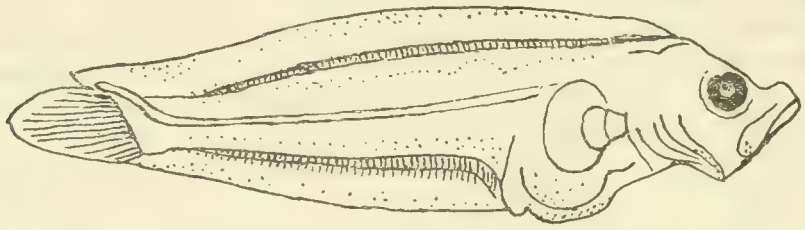

FIG. 239.—Larva (European), 16.2 millimeters. After Schmidt

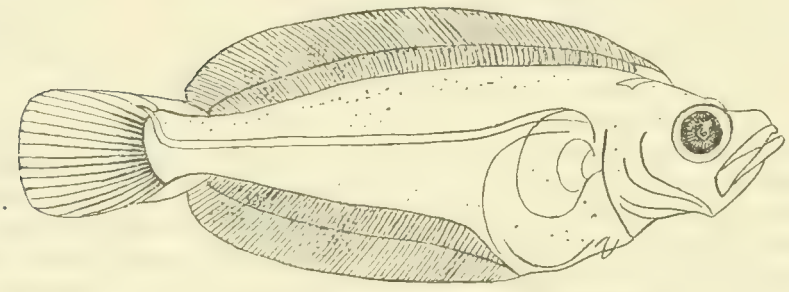

FIG. 240.—Larva (European), 22 millimeters. After Schmidt

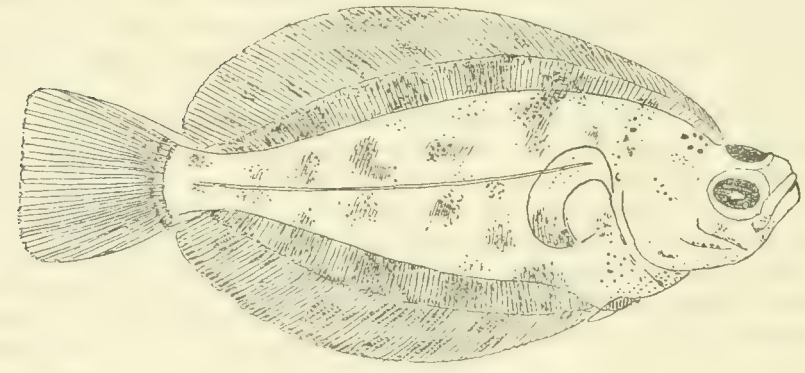

FIG. 241.—Larva (European), 34 millimeters. After Schmidt

Gulf of Maine (though "chickens" of 10 to 20 pounds are not uncommon there) as to suggest that the maintenance of the local stock depends on immigration from north and east more than on local propagation, and the fact that depletion by hard fishing was not accompanied by a corresponding decrease in the average size of the individual fish taken is further evidence to this effect. In fact, it is even doubtful

whether the halibut succeeds in reproducing its kind to any extent west of Cape Sable. There is a strong contrast in this respect between the Gulf of Maine and the waters around Iceland, where Jespersen found an abundance of little fish of 8 to 10 inches.

Large halibut are very prolific, the ovaries of a fish of about 200 pounds having been estimated to contain 2,182,773 eggs. Eggs spawned naturally have never been seen, but presumably they are not buoyant, and if buoyant they are among the largest of floating fish eggs, for they are 3.1 to 3.8 mm. in diameter as taken from the ripe ovary, with no oil globule.

The smallest halibut [53] yet seen was one of 13.5 mm., in which the vertical fin rays were first appearing. These are developed and the ventral fins are visible at about 22 mm. (fig. 240), by which time the left eye has moved upward until its margin is just visible above the contour of the head, forecasting the fact that the fish is destined to be right-handed. Fish of this size also show the large mouth characteristic of the species. Up to this stage there is little pigment. At a length of 27 mm. about one-fourth of the eye appears above the profile, but even at 34 mm. (the largest pelagic stage yet found) the eye has not entirely completed its migration (fig. 241), though the pigmentation is stronger on the right side than on the left, and the caudal fin, previously rounded, has become square tipped. The younger larvæ (up to about 25 mm. in length) are recognizable by the curiously upturned snout. Those large enough to show that they belong to some right-handed, large-mouthed flounder are easily separated from the American plaice larvæ (the only other Gulf of Maine flatfish, except for the very rare Greenland halibut, which they resemble in early stages) by the outlines of the head and abdomen. The smallest halibut yet taken on the bottom was about 4¾ inches long and already showed all the diagnostic features of the adult.

166. **Greenland halibut** (*Reinhardtius hippoglossoides* Walbaum)

TURBOT; GREENLAND TURBOT; AMERICAN TURBOT; NEWFOUNDLAND TURBOT

Jordan and Evermann, 1896–1900, p. 2611.

Description.—This is a right-handed, large-mouthed flatfish (that is, it lies on the left side with eyes on the right side and abdomen at the right edge), with slightly forked tail and symmetrical ventral fins like a halibut. In fact it so closely resembles the latter that it might easily be taken for one were it not that the lateral line is nearly straight (not arched) abreast of the pectoral, and that its long fins (dorsal and anal) are of rather different outline (compare fig. 242 with fig. 238), though with about the same number of rays (about 100 dorsal and 75 anal). Its mouth, furthermore, is larger and its jaw teeth stronger, though the difference in these respects is not sufficient to serve as a useful field mark. It is described (we have never seen it) as yellowish or grayish brown, paler below than above but not white.

[53] What little we know of the early stages of the halibut is due to European students, chiefly to Schmidt (Meddelelser fra Kommissionen for Havundersøgelser, Serie: Fiskeri, Bind I, Nr. 3, 1904) and Jespersen (Ibid., Bind V, Nr. 5, 1917).

Size.—Next to the halibut this is the largest North Atlantic flatfish, growing length of about 40 inches and a weight of 20 to 25 pounds, but fish caught about the Grand Banks average only about 5 to 10 pounds.

General range.—Arctic-Atlantic. It is caught about Newfoundland, on the Grand Banks, along the Scotian Banks, and as far south on the American coast as the Eastern Channel off Cape Sable.

Occurrence in the Gulf of Maine.—We mention this Arctic fish here on the strength of Goode and Bean's (1879g, p. 40) statement that "fishermen take them frequently in the gully between La Have and Georges Banks at depths greater than 200 fathoms;" and as no one has reported a Greenland halibut from the Gulf of Maine since that time, nor from the continental slope anywhere west of the Eastern Channel, the latter is evidently its southern limit.

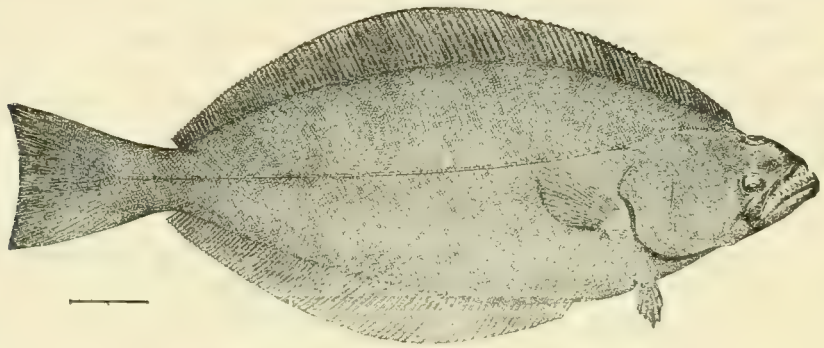

FIG. 242.—Greenland halibut (*Reinhardtius hippoglossoides*)

167. **American plaice** (*Hippoglossoides platessoides* Fabricius)[54]

CANADIAN PLAICE; SAND DAB; ROUGH DAB; PLAICE; TURBOT; FLOUNDER; SOLE

Jordan and Evermann, 1896–1900, p. 2614.

Description.—The most obvious diagnostic characters of the American plaice are that it is right-handed and large-mouthed like the halibut but with rounded instead of forked tail, and with a straight instead of an arched lateral line, being the only Gulf of Maine flounder in which these characters are combined. Our only other large-mouthed flatfishes with rounded tails (the sand, summer, and four-spotted flounders, pp. 516, 491, and 494) are left-handed. The wide-gaping jaws mark the plaice at first glance from the various small-mouthed flounders.

The plaice is a comparatively broad (really deep) flounder (about two and one-half times as long as broad), more rounded in outline than the halibut, with pointed nose, mouth gaping back to abreast the middle of the eye, and one irregular row of sharp conical teeth in each jaw. The free edges of the scales of the entire upper body and head are serrated with sharp teeth, which give the fish a characteristic rough feeling when handled, but those of the lower (blind) side are smooth-edged except on the rear part of the body and along the bases of the fins. The dorsal

[54] Various other common names are applied to this fish in different seas. It is usually termed "long rough dab" in England and is so listed in British fishery statistics. It is not the "plaice" of Europe.

fin (76 to 96 rays) originates in front of the middle of the left eye and the anal (64 to 77 rays) abreast of the pectoral and close behind the gill opening. These long fins taper both toward the head and toward the tail, while there is a short, sharp, spine (the prolongation of the post abdominal bone) pointing forward close in front of the anal fin. The pectoral fin on the eyed side usually (not always) has one or two more rays and is longer and more rounded than its fellow on the blind side, but the two ventral fins, which are close in front of the anal though entirely distinct from it, are alike in size, shape, and location. The margin of the caudal fin is always convex, either rounded or with its middle rays so much the longest as to form a blunt angle. The lateral line is more clearly evident in the plaice than in most of our flatfishes and practically straight from end to end.

Color.—Plaice run more uniform in color than most of our smaller flatfish, ranging from reddish to grayish brown, dark or pale, above and pure or bluish white below. Small fish usually show 3 to 5 dark spots along each edge of the body; large ones do so occasionally, though they are usually plain colored.

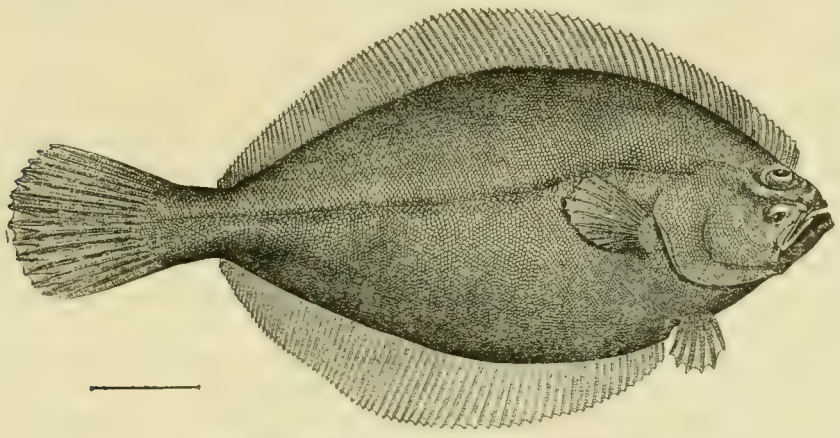

FIG. 243.—American plaice (*Hippoglossoides platessoides*)

Size.—The maximum length is about 2 feet and they weigh up to 7 pounds. According to Huntsman (1918), Bay of Fundy and Nova Scotian fish average about half a pound at 12 inches, 1¼ pounds at 16 inches, 1¾ pounds at 18 inches, 2¾ pounds at 20 inches, 4 pounds at 22 inches, and 6 pounds at 24 inches, while Massachusetts Bay fish are about as heavy at corresponding lengths. Adults caught off Cape Ann and measured by Welsh ran from about 12 to 24 inches in length, averaging 14 or 15. They average slightly larger in the colder water of the Gulf of St. Lawrence.

Plaice tend to differentiate into local races in different seas. Thus the fin rays are more numerous, on the average, in fish from high latitudes than in those from low latitudes, while the body is relatively wider in fish caught off Greenland and America than in Scandinavian or North Sea specimens. But these characters vary so widely even in limited areas that the Arctic-American and European "species" (*platessoides* and *limandoides*) have been united by common consent long since, and we doubt whether the corresponding "varieties" still recognized by several recent

authors will stand the test of time more successfully. Huntsman's statement that the dorsal rays average more numerous in plaice from Bay of Islands, Newfoundland, than in those caught on the New Brunswick shore of the Gulf of St. Lawrence, with Welsh's note of a variation of 7 in the number of dorsal and of 6 in the anal rays in one lot of fish caught off Gloucester, illustrates this variability. Notwithstanding the low latitude of the locality of capture (about 42° 30′ N.) this same lot contained a specimen with the largest number of fin rays yet reported (96 dorsal and 77 anal). Until many more specimens are examined all that can be said is that hereditary local races may perhaps exist off different parts of the American shore line, though it may prove that the structure of the scales, in connection with the length of the fish, will give a clue to the local origin of a given specimen, for the rate of growth is governed by the temperature of the water (p. 486).

General range.—This is a very common fish on both sides of the North Atlantic, its range closely paralleling that of the halibut. It is found off the whole North American coast from the Straits of Belle Isle, the Gulf of St. Lawrence, and the region of the Grand Banks to Cape Cod, and across the whole breadth of the continental shelf from close inshore out to the 100-fathom contour. West of Cape Cod plaice are caught in the Woods Hole region, off Marthas Vineyard, and off Narragansett Bay, which is in general their western limit.[55] It has not been recorded from the eastern coast of Labrador north of Belle Isle though common in west Greenland waters, hence may shun the very low temperatures of the Labrador current, as seems to be true of the halibut. Nor is it known from the Arctic coasts of either continent except in the comparatively warm water off the Murman coast. In European waters it ranges from Iceland and Spitzbergen to the North Sea, where it is an important commercial fish, and to the west Baltic, with the English Channel as its southern boundary.

The American plaice may be described as boreal-Arctic in its relation to temperature, reaching its highest development in water of 35° to 45°, able to live, however, in the lowest Polar temperatures (29° to 30°), and finding the upper temperature limit to its regular occurrence at 50° to 55°.

In different seas plaice live through a wide range of salinity from 30 per mille or lower in the Baltic to upwards of 34 per mille, but, so far as we are aware, they are never found in water which could be described as brackish.

Occurrence in the Gulf of Maine.[56]—One would hardly guess how common and generally distributed the plaice is in suitable depths and on suitable bottom in the Gulf, from reading what has been published on Gulf of Maine fishes, nor do the local fishery statistics help in this respect, for plaice are combined there with other flatfish as "flounders" This is not as familiar a fish as are the winter and smooth flounders (pp. 501 and 508), not being common in water shallower than 15 to 20 fathoms, but it is probably the most abundant of all Gulf of Maine flatfishes below that depth, except, perhaps, the witch. Plaice are recorded, in print, from Provincetown, from Massachusetts Bay, off Cape Ann, in Ipswich Bay, near Boon Island,

[55] We find no credible records from New York or from New Jersey, those mentioned by DeKay being market fish which might have come from anywhere to the eastward.

[56] Huntsman (1918) gives an interesting account of this fish in Canadian waters.

off Cape Porpoise, off Casco Bay, off Seguin, south of Monhegan (we trawled them at the last four localities on the *Grampus*), in Passamaquoddy Bay, in St. Mary Bay, and right up to the head of the Bay of Fundy. In fact, they are to be caught on hook and line or in the otter trawl all around the periphery of the Gulf in depths of 15 fathoms or more wherever the bottom is smooth and not too soft. They are certainly common on Georges Bank, for they were repeatedly reported there by representatives of the bureau in 1913, though no record was kept of the number actually taken because they were not marketable. We also have the definite evidence of the capture of newly spawned eggs in the tow net that there are plaice on Browns Bank as well. Huntsman, from fishing experiments, has calculated that plaice are about one-tenth as numerous as cod (one-twentieth in weight) in the Gulf of St. Lawrence, and while no estimate of this sort is yet possible for the Gulf of Maine it is certain that the local stock is sufficient to afford a large supply were there a market for it. Welsh, for example, recorded the following catches of plaice in gill nets (gear not very well adapted for flounder fishing) during the spring of 1913: Seventy-six plaice to 1,055 haddock, 51 cod, 20 pollock, and 39 rosefish near Boon Island on March 30; 125 plaice to 40 other flounders, 89 cod, and 113 haddock in part of the net at the same locality on April 20; and many plaice, but more cod and haddock, on May 3.

We have never seen or heard of an adult plaice taken in less than 10 fathoms in the Gulf of Maine, though even the large ones have been caught in water as shoal as 5 fathoms off Iceland, and they are most plentiful in 15 to 60 fathoms. Eighty-six fathoms is the deepest definite record for the Gulf of Maine with which we are acquainted, and probably 100 fathoms may be set as the lower limit to their occurrence there in any numbers, which applies to the whole American coast line, including the Scotian and Grand Banks. Since plaice have been caught as deep as 350 fathoms in Davis Strait, however, it is the type of bottom or the food supply that limits their dispersal downward, not the depth of water *per se*. On the other hand Huntsman has suggested that it is to avoid the strong light of day that this fish shuns shoal water—a suggestion yet to be proven by actual experiment. The preference of the plaice for moderately deep water bars it from most of the Gulf of Maine harbors and river mouths, such favorite haunts of the winter flounder, but it enters the deeper estuaries, particularly in the northeastern part of the Gulf—Passamaquoddy Bay, for example, and St. Mary Bay.

Plaice, like other flatfish, avoid rocky or hard bottom on the one hand and the very soft oozy mud of the deep basin on the other, preferring the fine sticky but gritty mixture of sand and mud that floors much of the Gulf between the hard patches from the 20-fathom contour out to the 100-fathom contour.

Food.—Huntsman's (1918, p. 15) statement that the plaice feeds first on minute plants (diatoms) and on copepods as it grows larger and more active is the only information available on the diet of the young fry while living at the surface. When they first take to the bottom they eat small shrimps and other Crustacea of various sorts; but as they grow they turn to a diet consisting chiefly of sea urchins, sand dollars, and brittle stars, as proved by the contents of their stomachs, though they also take various shrimps, hermit and spider crabs and other crustaceans,

mollusks, worms and ascidians ("sea squirts")—in fact, practically any animals living on bottom that are small enough for them to devour. Occasionally they catch small fish. Plaice do not bite a baited hook very readily, partly, no doubt, because they are sluggish fish, but partly, we believe, because the clams, cockles, and herring usually employed for bait are not their favorite food.

All the large predaceous fish that feed near bottom probably prey more or less upon the plaice, and halibut no doubt destroyed great numbers of them in the Gulf of Maine formerly, for flatfish of one sort or another bulk large in their diet. However, the adult plaice can have no serious enemy in the Gulf to-day except the cod and perhaps the spiny dogfish. In more northern seas Greenland sharks prey regularly on them. Smitt [57] and Huntsman both speak of the numbers of round worms to be found in the intestines and body cavity of plaice, and its gills are sometimes attacked by parasitic copepods.

Habits.—Plaice are bottom fish like other flounders, usually lying flat on the ground,but they must rise some distance from the mud on occasion and move about to a considerable extent to account for the capture of so many in gill nets, while we once caught one a foot long in a tow net at least 5 to 10 fathoms above the bottom off Ipswich Bay, where the water was about 50 fathoms deep.

Rate of growth.—The young plaice seeks bottom when about an inch and a half long, after which its rate of growth depends on the temperature of the water and probably on the length of the growing season, for growth practically stops during the winter. Thus Huntsman (1918) has found that it takes 3 to 5 years for a plaice to grow to a length of 12 inches in Passamaquoddy Bay where the temperature of the bottom water in 15 to 18 fathoms warms to about 49 to 51° in August,[58] 4 to 6 years in the open Bay of Fundy where the bottom temperature is somewhat lower (45 to 48°); 6 to 9 years in the cooler water (about 38°) of Chedabucto Bay in the Straits of Canso; and upward of 8 years in the still lower temperatures (colder than 35°) of the Gulf of St. Lawrence. Plaice living in the deeper parts of the Gulf of Maine may be expected to grow at about the same rate as the Bay of Fundy fish, while those living on Georges Bank and in the coastal zone from Cape Cod to Cape Elizabeth probably do so as fast as the Passamaquoddy Bay fish—that is, they may reach a length of 15 inches in 5 years or even sooner, and by that age, according to Huntsman, they may gain 11 ounces in weight yearly. Some plaice become sexually mature when only 6 inches long, probably all of them do so by their third year, and they may live to an age of 24 to 30 years.

Although plaice grow so much more rapidly in the comparatively warm water of Passamaquoddy Bay than in lower temperatures, large ones are far less common there or in the Bay of Fundy than in the Gulf of St. Lawrence, where fish 10 to 12 years old and of corresponding size form a considerable proportion of the stock, a discrepancy which Huntsman explains by assuming a higher death rate in warm waters than in cold. However, a study of the composition of the stock in other parts of the Gulf of Maine and especially that of its southwest part, where plaice spawn freely (p. 487), may show that the older fish simply move out of the Bay of Fundy.

[57] Scandinavian Fishes, 1892.

[58] Craigie, Contributions to Canadian Biology, 1914–15 (1916), pp. 151–161.

Migrations.—While the young plaice is living at the surface (p. 491) it undergoes the same involuntary journeyings that overtake other fish fry spawned at the same place and time, but from the time it seeks bottom it is one of the most stationary of fishes. It has been said to work inshore more or less in winter, though not on very definite evidence, and it may congregate on certain grounds for spawning, though this is yet to be proven, but it is certain that wherever plaice are plentiful they are to be caught at any season. Huntsman (1918, p. 18), who has paid special attention to this fish, believes that it "remains pretty much in the same place from season to season and year to year. Perhaps in the course of years it may shift a few miles."

Breeding habits. –The plaice is a spring spawner. Our earliest record of its eggs in the Gulf of Maine was for March 4 (in 1920), when they occurred in some numbers off Casco Bay. We also found eggs on Browns Bank on the 13th, and Welsh records large female plaice, half spent and with eggs exuding, and males with running milt, near Cape Ann on the 14th of March in 1913; but since other fish of both sexes taken with them were still unripe it is probable that spawning is not general until the last of that month or the first days of April. Plaice eggs have appeared regularly in our tows at the shallower stations in April (twice in great numbers, namely, off Seguin Island on the 10th and off Mount Desert Island on the 12th in 1920), and spawning continues unabated throughout May, for in 1915 eggs occurred at practically all our May stations. Our latest record was for a single egg on the 14th of June in 1915, and April and May similarly cover the height of the spawning season in the Bay of Fundy according to Huntsman (1918, p. 14).

The plaice breeds later in the northern part of its range than in the southern part. On the banks off Cape Breton and in the southern part of the Gulf of St. Lawrence it spawns chiefly during May and June, and on the Newfoundland Banks it continues to do so until the end of July, when a few eggs were found by the Canadian Fisheries Expedition. Huntsman also remarks that there is a difference in the breeding season according to the depth of water, those living shoalest commencing to spawn first as the vernal warming of the water makes itself felt from above, but we have no clear evidence on this point to offer for the Gulf of Maine. This fish spawns somewhat earlier in the North Sea than in American waters—that is, from mid-January till May with the climax in March and April.

Our egg records and Huntsman's observations show that the plaice spawns all around the Gulf of Maine from Cape Cod on the west to Cape Sable on the east, including the Bay of Fundy, and from close inshore out to the 50-fathom contour. It likewise spawns on Browns Bank (p. 487), and, while we found no eggs on Georges Bank either in February, March, April, or May of 1920, the fish is so common there and so stationary in its general habit that it is likely that we simply missed its eggs there, either by a failure to tow over the precise spawning beds or by timing our visits between waves of reproduction. Plaice also spawn abundantly east and north of Cape Sable, particularly off Cape Breton, on Sable Island Bank, and in the shoaler parts of the Gulf of St. Lawrence.[59]

[59] Dannevig. Canadian Fisheries Expedition, 1914-15 (1919), p. 18, figs. 11, 12, and 13.

Although the plaice may be considered rather a deep-water fish compared to most other flounders common in the Gulf of Maine, it spawns there chiefly in water shoaler than 50 fathoms as do all its relatives except the halibut. In fact it is doubtful whether plaice ever spawn deeper in the Gulf, for we have few egg records from more than a mile or two outside the 50-fathom curve and these few are based on only one or two eggs each.

There is no reason to suppose that plaice gather in definite localities to spawn, except that those living deepest must work up into shoaler grounds to account for the concentration of our egg catches inside the 50-fathom contour.

The temperatures and salinities in which the eggs are produced can be stated with confidence for the Gulf of Maine because the plaice lies very close to, if not actually on, the bottom. The earliest spawning takes place at nearly the minimum temperature for the year, averaging about 37° for all the March and April stations; and while the water warms to 41° to 43° by late May and early June at the depths inhabited by the ripe fish we have not found its eggs where the bottom temperature was higher than about 40°. Thus the optimum for breeding may be set at 37° to 40° for the Gulf of Maine as a whole. Plaice spawn freely in 31° to 32° off Cape Breton, and even in water as cold as 29.3° to 36° in the Gulf of St. Lawrence, proving that the lowest Polar temperatures are no bar to the ripening of the sexual products. It is probable, however, that somewhat warmer water is requisite for the normal development of the eggs and survival of the resultant larvæ, a point calling for experimental investigation.

The Gulf of Maine plaice spawn in relatively low and uniform salinities, the range being only from about 31.8 per mille to 32.8 per mille at the bottom at the stations where eggs were taken in any number. Although plaice spawn so generally throughout the whole area which it inhabits there is evidence that different regions differ in their suitability as nurseries either for the eggs or for the newly hatched larvæ. The southwestern part of the Gulf of Maine must be favorable in this respect, for we have taken larval plaice at 14 stations there, most of these off the Massachusetts Bay region, and they have also been taken at various localities off the southeast coast of Nova Scotia, on the Newfoundland Banks, and in the Gulf of St. Lawrence. However, it seems that reproduction does not succeed in the Bay of Fundy, for neither larvæ nor young fry are known there in spite of the fact that plaice spawn and eggs develop at least partially. We have failed equally to find any plaice larvæ off the coast of Maine east of Penobscot Bay, though eggs are produced there in abundance (fig. 244). The case is complicated by the strong probability that there is a general drift from northeast to southwest along this part of the coast, and hence that buoyant eggs spawned there might hatch a considerable distance west of where they were produced. The influence which this drift may have on the distribution of larval fish in the Gulf of Maine offers a most fertile field for future study.

The plaice is a prolific fish, individual females producing 30,000 to 60,000 eggs, according to size. The eggs are buoyant, without oil globule, but with a perivitelline space so broad that they are not apt to be confused with any other species. This space forms after the eggs are shed by the entrance of water between

the egg proper and its covering membrane, and it about doubles the total diameter. The plaice eggs we have taken in the Gulf of Maine have averaged about 2.5 mm. in diameter, but they have been reported as small as 1.38 and as large as 3.2 mm. in other seas, depending on the breadth of the perivitelline space.

Incubation occupies 11 to 14 days at a temperature of 39°, and it seems that the eggs gain in weight as development proceeds, for in the Gulf of St. Lawrence Huntsman found the newly spawned eggs floating on the surface, but those which

FIG. 244.—Locality records for plaice eggs (●) and larvæ (▲)

were nearly ready to hatch hanging suspended at a depth of some 10 fathoms. We have no first-hand information to offer on this point. During the development of the egg minute black and yellow pigment cells are scattered over the embryo, not aggregated into any diagnostic clusters, but very soon after hatching (which takes place when the larvæ are 4 to 6 mm. long) the pigment gathers in five definite groups—one on the gastric region, one about the vent, and three post anal bands, a pattern similar to that of the larval witch flounder (p. 515).

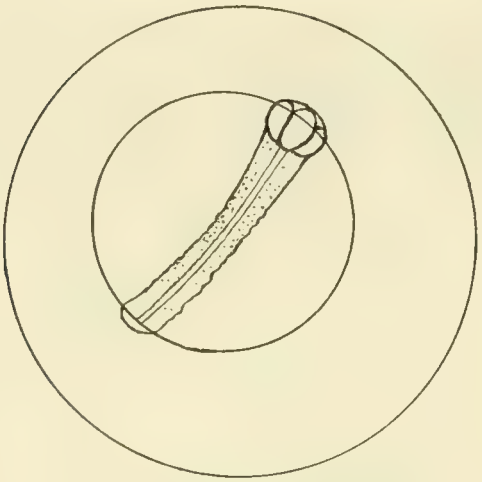

FIG. 245.—Egg (European). After Cunningham

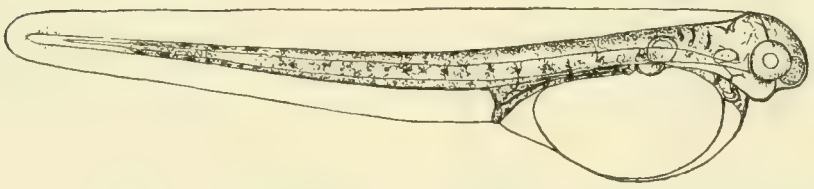

FIG. 246.—Larva (European), just hatched, 4 millimeters. After McIntosh

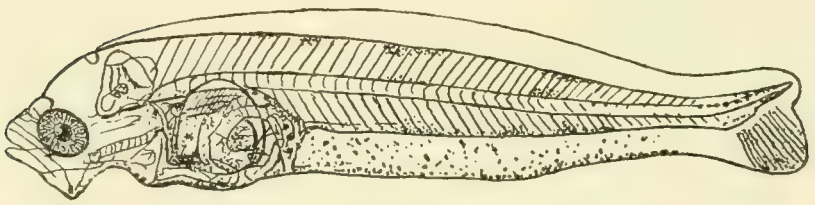

FIG. 247.—Larva (European), 9 millimeters. After Ehrenbaum

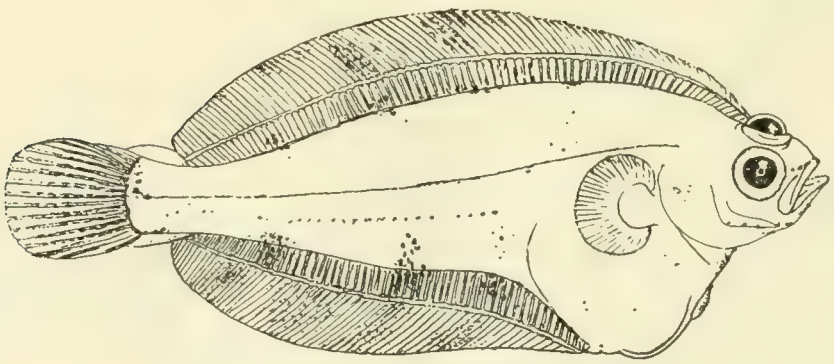

FIG. 248.—Larva (European) 31.5 millimeters. After Petersen

AMERICAN PLAICE (*Hippoglossoides platessoides*)

The yolk is absorbed about 5 days after hatching, when the larva has grown to 6.2 to 7.5 mm. in length. The caudal rays appear shortly after this, the dorsal and anal rays at about 11 to 12 mm., and the 3 vertical fins are differentiated at about 15 to 18 mm., by which stage the body has begun to assume the deep but very thin form characteristic of all young flounders while the jaws have developed sufficiently to show that the little fish belongs to one of the large-mouthed species. The left eye may commence its migration when the larva is about 20 mm. long, while Welsh found it visible above the outline of the snout in Gulf of Maine specimens of 24 mm. and almost at the dorsal ridge at 34 mm., but in other seas larvæ as long as 35 mm. may still be symmetrical. The only other Gulf of Maine species for which the larval plaice might be mistaken (except in its very earliest stages) are the witch flounder and the halibut; but the witch is longer at corresponding stages of development but with the distance from snout to vent proportionately much shorter, and the outline of throat and abdomen are sufficiently different to distinguish the plaice from the halibut (p. 481).

Up to the time of its metamorphosis the young plaice lives pelagic, as do the young of most sea fishes, keeping close to the surface at first but sinking deeper as it grows, until finally it takes to the bottom. Young plaice, like many other pelegic animals, sink more or less regularly by day, to rise toward the surface of the water by night.

Welsh's observations suggest that the plaice commences its life on the bottom at a length of about 1½ to 1¾ inches, with its metamorphosis already complete, its body scaly, and its eyed side densely pigmented. There is wide variation in this respect, however, and according to European authors the fry may even take to the bottom before the left eye has completed its migration around the head.

The period occupied in larval growth and metamorphosis varies with temperature, probably about three to four months being a fair estimate for the Gulf of Maine, where we have taken the pelagic larvæ of the plaice as early in the season as May 26 and as late as August 2; and by the first winter the little fish grow to a length of 2 to 3 inches, their exact size depending upon how early in the season they are hatched and probably on the temperature in which they live.

Commercial importance.—Although the plaice is an excellent pan fish, in fact one of the best of Gulf of Maine flounders, there is so little market for it that few are brought in.

168. **Summer flounder** (*Paralichthys dentatus* Linnæus)

FLOUNDER; FLUKE; PLAICE; PLAICEFISH; TURBOT

Jordan and Evermann, 1896–1900, p. 2629.

Description.—The summer flounder is left-handed. That is, it lies on the right side with its eyes on the left side and its abdomen on the left edge as it rests on the bottom (this differentiates it at a glance from the plaice), and it is large-mouthed like the sand flounder, which is similarly left-handed (p. 516); but its two ventral fins are alike and both are separated by a considerable space from the long anal, whereas the upper ventral fin of the sand flounder is continuous with the anal. The only Gulf of Maine flatfish with which the summer flounder shares its left-

handedness, large mouth, and symmetrical ventral fins is its close relative, the four-spotted flounder, but the color pattern of the latter is distinctive (p. 494) and its fin rays are fewer in number. The summer flounder is one of the narrower flounders. Its dorsal fin (about 87 rays) originates opposite the forward margin of the eye, its anal is of about 68 rays, the margin of its caudal is rounded, and its pectorals and ventrals are relatively smaller than those of the plaice.

Color.—It has long been known that flounders are generally dark on a dark bottom and pale on a pale one. Perhaps the summer flounder is the most variable in color of all our local species and the one which most closely adapts its pattern to that of the ground on which it lies. Like most flounders it is white below and of some shade of brown, gray, or drab above, but it can assume a wide range of tints from nearly white on white sand through various hues of gray, blue, green, orange, pink, and brown to almost black. Red alone did Mast[60] find it unable to match. As a rule its upper surface is variegated with pale and dark, with the pattern fine or coarse according to that of the bottom, and it may or may not be marked

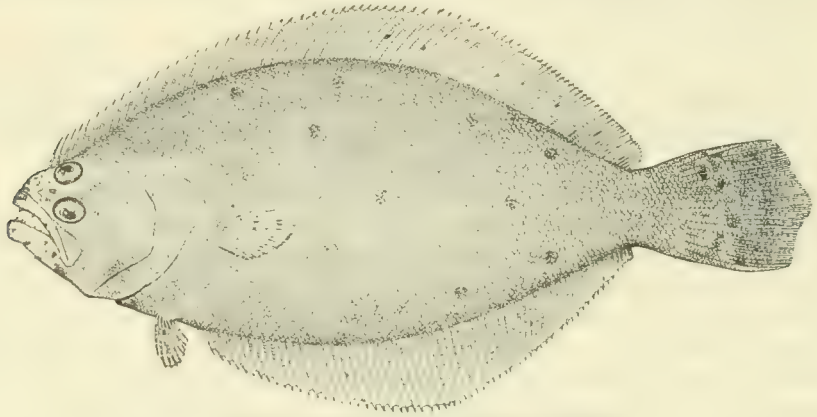

FIG. 249.—Summer flounder (*Paralichthys dentatus*)

with small eyespots of a darker tint of the general ground color. Masts's experiments show that it is slower in adapting its coloration to the actual colors of the bottom than to the general pattern, responding most rapidly to yellows and browns and very slowly to reds, greens, or blues, on which the adaptation may not reach its maximum for two or three months. He also observed that the skin simulates rather than exactly reproduces the pattern of the background.

Size.—Summer flounders grow to a maximum weight of 10 to 25 pounds and to a length of 3 feet, while the largest of which we find definite record weighed 26 pounds, but the average size of the fish caught is only 2 to 5 pounds. The relation of length to weight appears from the following table: [61]

Length	Average weight
15 inches	1 pound
17 to 18 inches	2 pounds
20 inches	3 pounds
22 inches	4 pounds
27 inches	8 pounds
30 inches	10 pounds

[60] Mast. Bulletin, United States Bureau of Fisheries, Vol. XXXIV, 1914 (1916), p. 177. [61] From Goode, et al., 1884.

General range.—Shoal coastal waters off the eastern United States from Maine to South Carolina, possibly to Florida,[62] and chiefly south of Cape Cod.

Occurrence in the Gulf of Maine.—This is the commonest and commercially the most important flatfish west and south of Rhode Island, but its range barely rounds Cape Cod, and Cape Cod Bay seems always to have been the boundary to its regular occurrence. North of this it is so rare a straggler that there is only one definite record—for Casco Bay (specimens collected in 1873). We may add that we have never seen nor heard of one caught in the inner part of Massachusetts Bay and that it is unknown in the Bay of Fundy.

The neighborhood of Provincetown is the most northerly locality where the summer flounder has ever been known to occur in abundance, but it was so common there and along the inner side of Cape Cod as far as Wellfleet during the period from 1840 to 1850 that Captain Atwood carried them regularly thence to Boston and records catching 2,000 pounds in a single afternoon inside Provincetown Harbor. However, summer flounders so diminished in number after a few years of hard fishing that Goode (et al., 1884, p. 175), writing in 1884, described them as "only occasionally taken" there; and so far as we can learn they have never reappeared in any abundance within the limits of the Gulf of Maine, a fact suggesting that the local body of fish concerned was not actually very large and that it received but few accessions from the more abundant stock south of Cape Cod. Since Dr. W. C. Kendall caught summer flounders at Monomoy and at North Truro in 1896, however, occasional specimens are to be expected to round the tip of Cape Cod and to be taken in Cape Cod Bay.

The summer flounder occurs as far eastward as Georges Bank, offshore, where Welsh saw some taken in otter trawls in 1912 (exact locality not given), but no information is available as to its abundance there and it is probable that the Eastern Channel is its boundary in this direction. Being of so little importance, natural or commercial, in the economy of the Gulf we may pass over its habits briefly.

Habits and food.—It is a shoal-water fish, commonest in summer from tide mark out to 8 or 10 fathoms, often caught in bays and in harbors where it lurks among the piles of docks, and it runs up into fresh water in the mouths of rivers. Summer flounders prefer sandy bottom, mud, or eelgrass, and they are frequently seen lying covered all but the eyes in the sand, where it takes one but an instant to so bury itself. When disturbed they are swift swimmers.

This is a predaceous species like the halibut, feeding largely on small fish of all sorts, on squids, and likewise on crabs, shrimps, and other crustaceans, small shelled mollusks, worms, and sand dollars. It is very fierce and active in pursuit of prey, often following schools of fry or sand eels right up to the surface, to jump clear of the water in its dashes, actions very different from those of the sluggish plaice or winter flounder. In the northern part of its range it moves out from the shallows into deeper water in winter, no doubt to avoid the cold, June to October being the fishing season along shore—hence its common name. It is not known whether the summer

[62] Florida is usually given as the southern limit of this flounder, but it is possible that the early records from that State (there are no recent ones) actually referred to the "southern flounder" (*P. lethostigmus*), a common Floridian fish.

flounders that appear as far north as Provincetown winter near by or whether they migrate southward in autumn.

Practically nothing is known of its breeding habits. Presumably its eggs are buoyant like those of its close relative, the four-spotted flounder, and since the ovaries of fish caught in summer are immature it is supposed to spawn in autumn or winter, perhaps moving out into deep water for the purpose.

Commercial importance.—This is one of the best of flatfish on the table, and south of Cape Cod (where it is common) it provides amusement to many anglers, for not only is it a free biter on almost any bait but large ones often put up a strong resistance when hooked.

169. **Four-spotted flounder** (*Paralichthys oblongus* Mitchill)

Jordan and Evermann, 1896–1900, p. 2632.

Description. –This fish so closely resembles the summer flounder (p. 491) in its general makeup that we need mention only the points of difference. Most

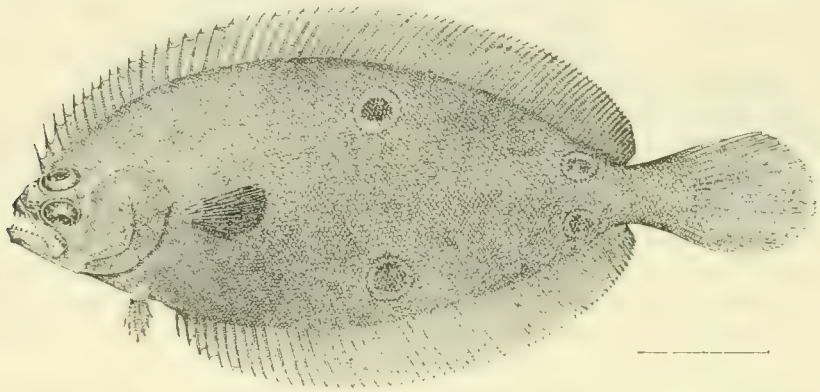

FIG. 250.—Four-spotted flounder (*Paralichthys oblongus*)

apparent of these are that it has fewer fin rays (only about 72 dorsal and 60 anal, as against 85 to 92 dorsal and 65 to 71 anal in the summer flounder), and that its mottled gray "back" is invariably marked with four large, oblong, and very conspicuous black eye spots edged with pale pinkish, two of them situated at each margin of the body, as the illustration shows (fig. 250). This is also a much smaller fish than the summer flounder, adults averaging only about 12 inches long with 14 inches about the maximum.

General range.—The limits of distribution of this fish are yet to be established, but its range is apparently very narrow for it has never been recorded south of New York on the one hand and only rarely north of Cape Cod on the other, though it is common along the intervening stretch of coast.

Occurrence in the Gulf of Maine.—This flounder has been reported from Monomoy at the southern angle of Cape Cod, from North Truro, Provincetown (where Storer saw a number of them in June, 1847), and from Gloucester Harbor,

where a single specimen was taken by the United States Fish Commission in 1878.[63] However, it is so rare about Massachusetts Bay that we ourselves have never seen or heard of one caught there of late years, and it is unknown farther north.

Habits.—Although this is a rather common fish about Woods Hole in May and June and still more so along the coast of New York, very little is known of its habits, but it seems to lie deeper as a rule than the summer flounder, usually being caught in 7 to 17 fathoms in Vineyard Sound.

Food.—The diet of the four-spotted flounder is much the same as that of its relative—that is, chiefly small fish and squid, with crabs, shrimps, shellfish, and worms.

Breeding habits.—This flounder spawns in May. Its eggs are buoyant,[64] about 0.96 mm. in diameter, and without oil globule. The larval stages have not been described previously, but certain larvæ of 8 to 11 mm. taken in our tow nets off the coast of New Jersey in 1913 (stations 10070 and 10082) are located in this genus by their large mouths and by left-handedness, which is foreshadowed in the larger ones by the fact that it is the *right* eye that has begun to migrate. The dates of capture (July 19 and August 1) suggest that they belong to the four-spotted and not to the summer flounder. If this identification be correct an aggregation of the pigment over the rear part of the trunk combined with relatively deep outline and a large head are likewise diagnostic. Small fry of 2 to 3 inches have been taken at Woods Hole in autumn, showing that this flounder completes its metamorphosis and takes to bottom about three months after hatching.

170. **Rusty dab** (*Limanda ferruginea* Storer)

YELLOWTAIL; DAB; RUSTY FLOUNDER; FLUKE; SAND DAB; MUD DAB

Jordan and Evermann, 1896–1900, p. 2644.

Description.—The dab is right-handed (that is, eyes on the right side and guts at the right-hand margin as the fish lies on bottom) and small-mouthed like the winter, smooth, and witch flounders; but it is easily distinguished from the first by its more pointed snout, thin body, arched lateral line, and more numerous fin rays; from the second by the last two characters as well as by the concave dorsal (left) profile of its head and by being scaly between the eyes; and from the third by its arched lateral line, its less numerous fin rays, the concave dorsal profile of its head, and especially by lacking the mucus pits on the left (white) side of its head, which are so conspicuous in the witch (p. 511).

The dab is a comparatively broad flounder, being nearly one-half as broad as long, with oval body. The dorsal outline of the head is more concave than in any other Gulf of Maine flounder, its head narrower, its snout more pointed, and its eyes set so close together that their rounded orbits almost touch each other. The fact that its mouth does not gape back as far as the eyes, with its small teeth and

[63] In one paper Goode and Bean (1879g, p. 40) state that this specimen was trawled in Gloucester Harbor. In another paper (1879, p. 7) they credit it to the mouth of Salem Harbor.

[64] They have been hatched artificially at the Woods Hole hatchery.

thick fleshy lips, marks it off at a glance from all the large-mouthed species of flounders. The dorsal fin (76 to 85 rays) originates over the eye, its middle rays longest, while the rays of the front half of the fin are free at the tips. The anal fin is similar in outline but much shorter (57 to 63 rays) and is preceded by a short,

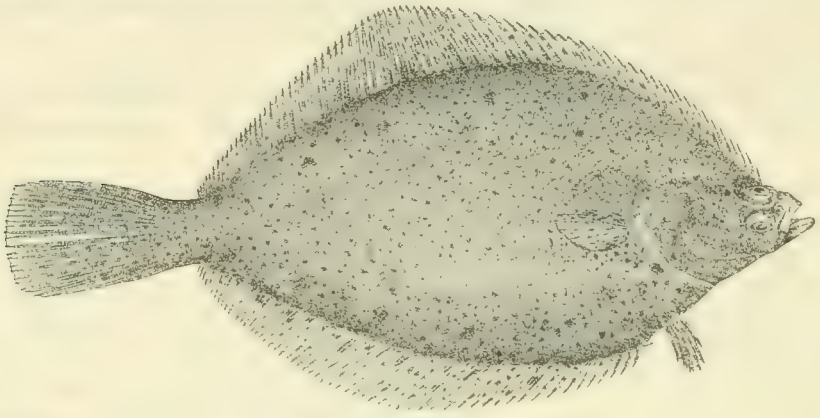

FIG. 251.—Adult

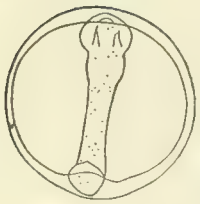

FIG. 252.—Egg

FIG. 253.—Larva, 10.3 millimeters

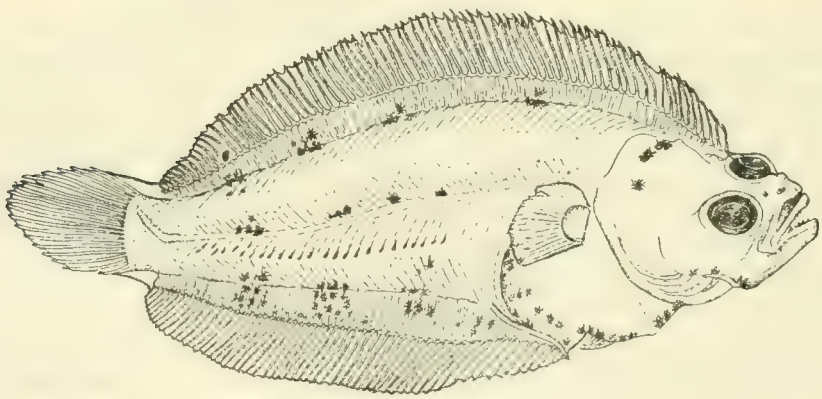

FIG. 254.—Larva, 14 millimeters

RUSTY DAB (*Limanda ferruginea*)

sharp spine pointing forward. The two ventral fins are alike and both are separated by a considerable space from the anal, but the pectoral on the blind side is slightly shorter than its mate on the eyed side. The scales are rough on the eyed side but smooth on the blind side.

Color.—The dab is more constant in color than most Gulf of Maine flounders, its eyed side, including the fins, being brownish or slaty olive tinged with reddish and marked with large irregular rusty red spots. The caudal fin and the margins of the two long fins are yellow, the yellow tail in particular being a very diagnostic character. The blind side is white, except for the caudal peduncle, which is yellowish.

Size.—This is a medium-sized flatfish. Several hundred adults caught in gill nets between Cape Ann and Cape Elizabeth (measured by Welsh) ran as follows: Males, average length 15¾ inches, extreme 11¾ to 18¾ inches; females, average 18 inches, extreme 15½ inches to 21¾ inches. This series includes the largest specimens that have ever been reported.

General range.—North American coastal waters, from the north shore of the Gulf of St. Lawrence, northern Newfoundland (there are specimens from St. Anthony's in the Museum of Comparative Zoology), and the Newfoundland Banks to New Jersey.[65]

Occurrence in the Gulf of Maine.—The dab is a rather deep-water fish, seldom seen along shore; and since its mouth is so small that one is rarely caught on the large hooks used for cod, pollock, or haddock, little was known of its distribution prior to the introduction of beam and otter trawls to the Gulf of Maine. Since then, however, the dabs (known locally as "yellowtails" or "flukes") have proved to be so plentiful along the sandy shores of the east side of Cape Cod Bay and on Stellwagen Bank below 10 fathoms that they and winter flounders together support a considerable trawl fishery there. No statistics of the actual catch of dabs are available (they are combined with other flatfish as "flounders"), but the Cape Cod fishermen marketed almost 3,000,000 pounds of these two species in 1908 and perhaps half of this amount were dabs. They are also common in the deeper parts of Massachusetts Bay, as Goode and Bean (1879) long ago remarked, and so many dabs are taken in gill nets (which are not very effective flounder gear) during the spring fishery for haddock between Cape Ann and Cape Elizabeth, especially between the Isles of Shoals and Great Boars Head where Welsh saw many hundreds during March and April in 1913, that this must be one of the commonest flatfish in the southern part of the Gulf in suitable depths.

Practically nothing is known of the abundance of dabs in the northeastern waters of the Gulf, though they have been reported off Casco Bay and in the Mussel Ridge Channel at the entrance to Penobscot Bay. Nor have our own inquiries of local fishermen elicited much information, few of them discriminating among the several offshore flounders. They are certainly rare and perhaps altogether absent from the Bay of Fundy, for Huntsman has found them only in

[65] This species is represented in north European waters by the European dab, *L. limanda*, a close ally, from which it is distinguishable by its smaller scales, more pointed snout, more numerous fin rays, and shorter pectoral fins.

We should also mention the deep-water dab (*L. beanii* Goode), for although it has not been taken within the limits of the Gulf of Maine it would not be surprising to find it on the seaward slope of Georges Bank, for it has been taken westward and southward from Marthas Vineyard in depths of 120 to 896 fathoms (the exact localities are listed by Goode and Bean (1896)). This flatfish is distinguished from the rusty dab by its much shorter head (occupying only two-elevenths instead of one-fourth of the total length), by the fact that the dorsal profile of its snout is convex and not concave, that it has only about 64 dorsal fin rays instead of 76 or more, that there are only 88 rows of scales along its lateral line instead of 90 to 100, and that its tail fin is marked with a conspicuous black blotch on the outer rays at each side.

St. Mary Bay—and but few there—nor have dabs been recorded from other parts of the west coast of Nova Scotia, though they are to be expected there. Welsh's experience was that dabs are rather common on Georges Bank generally, though no record was kept of the actual numbers caught, while the *Albatross* long ago trawled them on both the northern and the southeastern faces of the bank, and probably they also occur on Browns Bank though not yet definitely reported from there. The record of this species is very meager east of Cape Sable. It has been taken off Halifax, at Canso, on the Grand Banks, and at various localities in the Gulf of St. Lawrence, but nothing seems to be known as to its local abundance.

Turning to waters west of Cape Cod, dabs are plentiful all the year round on Nantucket Shoals and Sound, where they are one of the important commercial flounders, likewise in Vineyard Sound and Buzzards Bay in 7 fathoms and deeper, and they are common offshore as far as New York,[66] which is about the southern limit to their regular occurrence.

Habits.—Most of the dabs caught in the southwest part of the Gulf of Maine are in 10 to 30 fathoms of water, and the fish caught on Georges Bank are in 20 to 50 fathoms. Occasionally one is reported from shoal water, but generally speaking we believe about 5 to 7 fathoms may be set as its upper limit. Thus it lives considerably deeper than the winter or the smooth flounders. On the other hand, we find no record of dabs as deep as 100 fathoms in the Gulf, and most of them certainly live shoaler than 75 fathoms, while it is not likely that any descend into the deep basins where the mud is so soft and sticky that few flounders of any kind would be expected there. Most of the dabs that Welsh saw taken in gill nets on the Isles of Shoals-Boon Island grounds were living on fine black sand between the hard and rocky patches, and probably almost any sand or a mixture of sand and mud bottoms is suitable for them, but rocks, stony ground, and very soft mud are shunned by dabs as they are by other flounders.

Food.—The dab feeds chiefly on the smaller crustaceans such as amphipods, shrimps, schizopods, etc., and likewise on the smaller shellfish, both univalves and bivalves, and on worms. It is also known to eat small fish, but it is not likely that it can catch these often. Its European relative also feeds on sea urchins, starfish, and at times on algæ, and it is probable that the American dab would be found equally omnivorous were stomachs of fish from various localities examined. Fish in breeding condition usually are empty. The diet of the dab suggests that it is one of the more sluggish flatfish, and there is no reason to suppose that it ever travels about much after it once takes to the bottom except that it seems to move inshore in winter off southern New England [67] and offshore and deeper again as the water warms in spring, probably to avoid high temperature. If this actually takes place, however, it never leads the dab up into the shallows, and no migration of this sort has been observed north of Cape Cod. The rate of growth of the dab has not been studied.

Breeding habits.—Very little was known about the breeding of the American dab until recently when its season was determined and its eggs were artificially

[66] Nichols. Copeia, Dec. 27, 1913, No. 1, p. 4.

[67] Tracy, 1910, p. 163.

hatched through Welsh's industry. Spawning, as he found, commences near Gloucester by the middle of March, and many ripe fish were taken during the last half of April, but the majority were still green as late in the season as May 8 in 1913, though others were already spawned out; and since we have found eggs indistinguishable from those of the dab in our tow nets in June, July, August, and one even on September 11, and have taken its newly hatched larvæ (6 mm. long) off Race Point as late as August 31, spawning must last all summer. The individual females spawn over a considerable period of time, for Welsh found that only a small part of the eggs ripened simultaneously in any given fish.

The neighborhood of the Isles of Shoals and of Boars Head, where Welsh obtained his ripe fish, is certainly an important spawning ground at 20 to 30 fathoms. Probably the dab breeds over most of the peripheral belt of the Gulf of Maine between the 20 and 50 fathom contours except in the Bay of Fundy, but we have found no eggs over deeper water, and no doubt it spawns as actively on the offshore banks as it does alongshore, for although we have not actually found its eggs there we have taken larvæ only 7 to 11 mm. long over both the western and eastern parts of Georges Bank[68]; also near Gloucester and near the tip of Cape Cod, in July and August.

The dab also spawns on Sable Island Bank, Banquereau Bank, and the Newfoundland Banks, for eggs (no doubt of this species) were collected on these grounds by the Canadian Fisheries Expedition in 1915,[69] and, in the other direction, it breeds as far westward as New York, for we towed 88 young larvæ (6.5 to 19 mm. long) 11 miles off Sandy Hook on August 1, 1913.

The egg is buoyant, without oil globule, spherical, very transparent, and with a narrow perivitelline space. One hundred eggs measured by Welsh ranged from 0.87 to 0.94 mm. in diameter, averaging about 0.9 mm. The surface of the egg is covered with very minute striations, and while alive the germinal disk is of a very pale buff color. Shortly before hatching (which takes place in 5 days at a temperature of 50° to 52°) the embryonic pigment gathers in three groups—one on the head, one in the anal region, and a third half way between the latter and the tip of the tail. Unfortunately the fish which Welsh hatched were accidentally destroyed, so we can not describe the early larval stages. Larvæ of 11 mm. are still symmetrical, whereas at 14 mm. the left eye is already visible above the profile of the head, while all the fins are outlined, their rays are present in the final number (76 dorsal and 59 anal in the specimen illustrated), and the mouth is clearly fated to be "small." Thus, when they have reached this stage they show enough of the diagnostic characters of the adult for positive identification.

The early larval stages of dabs and of winter flounders resemble each other closely. In fact it is probable that some of the young flatfish pictured by A. Agassiz[70] as winter flounders were actually dabs. After the fin rays appear, however, their

[68] Station 10059, July 9, 1913; and station 10224, July 23, 1914.

[69] Dannevig (Canadian Fisheries Expedition, 1914–15 (1919), p. 17) refers these provisionally to the European dab, which does not occur on the American coast. Its egg is indistinguishable from that of the American species.

[70] Agassiz. Proceedings, American Academy of Arts and Sciences, new series Vol. VI, whole series Vol. XIV, 1879, Pl. IV.

number is usually diagnostic, placing the larvæ in one species or the other. While the dab does not take to bottom until upwards of 14 mm. long, the winter flounder completes its metamorphosis at a length of only 8 to 9 mm.

Williams's[71] observation (at Woods Hole) that the larvæ were completely metamorphosed when of the size just noted, supported by the position of the eye in the *Grampus* example (fig. 254), is evidence that the dab is not as long subject to involuntary migrations with the current as are some other flounders. Our

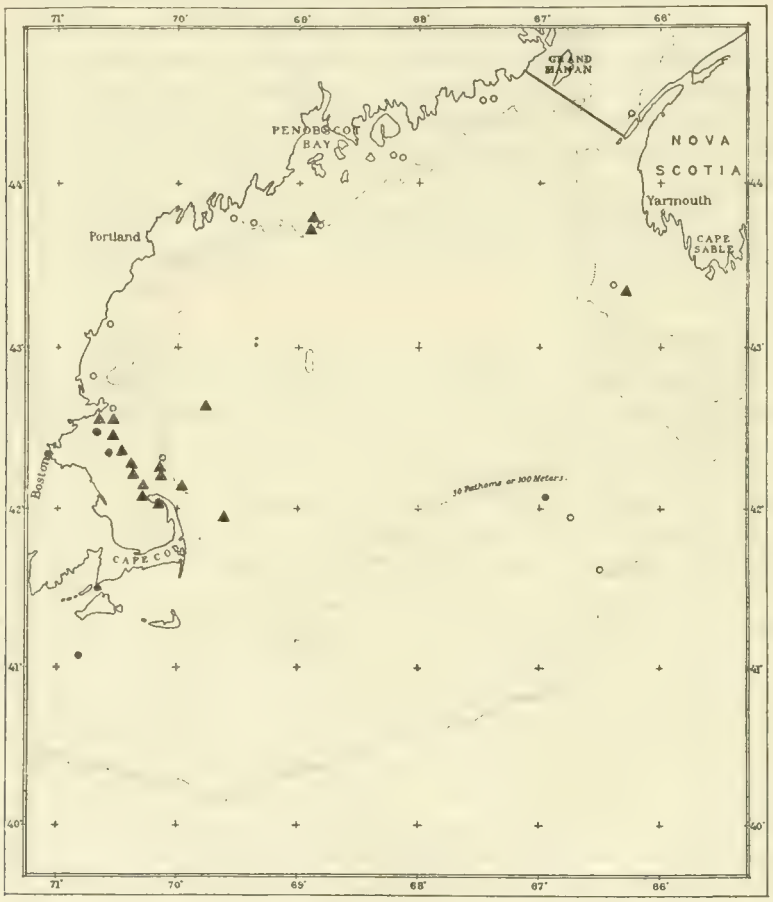

FIG 255.—Locality records for larvæ (●) of the dab, larvæ (▲) of the witch flounder, and eggs presumably referred to the dab (○)

records for its larvæ are all from the southwest part of the Gulf of Maine, from Georges Bank, and from west of Cape Cod (fig. 225).

Commercial importance.—This is hardly as desirable a table fish as the winter or summer flounders, not from any lack of flavor but because its body is thinner, but those taken in the Massachusetts flounder fishery find a ready sale with other flatfishes.

[71] Bulletin, Museum of Comparative Zoology at Harvard College, Vol. XL, 1902-3, No. 1, pp. 1-58, pls. 1-5.

171. **Winter flounder** (*Pseudopleuronectes americanus* Walbaum)

FLOUNDER; SOLE; FLATFISH; ROUGH FLOUNDER; MASSACHUSETTS FLOUNDER; MUD DAB; BLACKBACK; BLACK FLOUNDER

Jordan and Evermann, 1896–1900, p. 2647.

Description.—This is a small-mouthed, right-handed species (eyes on the right side and guts on the right), easily separable from the dab, which is similarly characterized, by the fact that its lateral line is nearly straight (at most only slightly bowed abreast the pectoral fin), the dorsal profile of its head less concave, its nose blunter, its eyes farther apart, its fin rays less numerous, and its fins less tapering in outline. The most obvious difference between the winter and the smooth flounders (p. 508) is that the former is rough scaled between the eyes, the latter smooth, and that the winter flounder has more fin rays. On the other hand it has

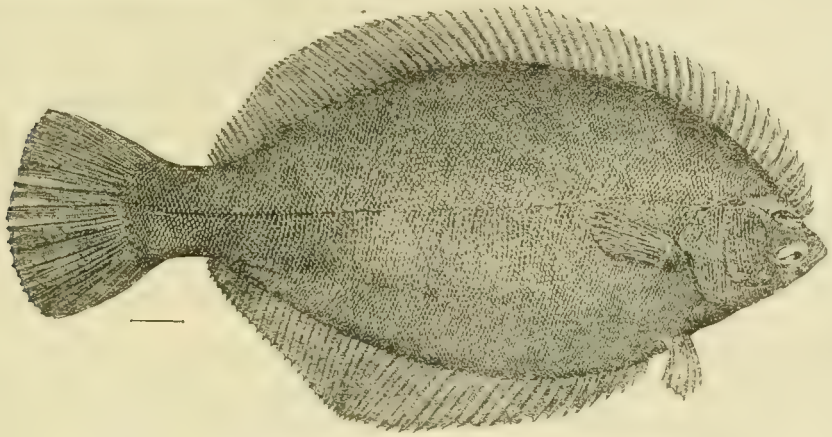

FIG. 256.—Winter flounder (*Pseudopleuronectes americanus*)

only about two-thirds as many dorsal rays as the witch (p. 511), lacks the mucus pits characteristic of the left (lower) side of the head of the latter, and has a much larger tail, proportionately. It is oval in outline, about two and one-fourth times as long as wide, thick-bodied, and with proportionately broader caudal peduncle and tail than any of our other small flatfish except its newly discovered relative, *P. dignabilis* (p. 507). The dorsal fin (61 to 69 rays) originates opposite the forward edge of the eye, and is of nearly equal height throughout its length. The anal (46 to 51 rays) is highest about midway and is preceded by a short, sharp spine. The ventral fins are alike on the two sides of the body, and both are separated from the anal by a considerable gap. The mouth is small, not gaping back to the eye, and the lips are thick and fleshy like those of the dab. The left (under) half of each jaw is armed with one series of close-set incisorlike teeth, but the right (upper) side has only a few teeth, or may even be toothless. The scales are rough on the eyed side, *including the space between the eyes*, but perfectly smooth to the touch on the blind (white) side.

The winter flounder shows some tendency to break up into local races with regard to the number of its fin rays [72] and perhaps in other characteristics, but it remains to be seen whether these varieties are sufficiently distinct or constant to give a clue to the local origin of individuals or of particular bodies of fish.

Color. –The winter flounder, like other flatfish, varies in hue according to the bottom on which it lies, but as a general rule it is the darkest of Gulf of Maine flatfishes. Large ones are usually of some shade of muddy or slightly reddish brown or dark slate above, sometimes almost black, and they vary from plain or more or less mottled to definitely dotted with small spots of a darker shade of the general ground tint. We have often noticed that there is usually a wide variation in this respect among any lot of flounders. The blind side is white. The long fins are usually tinged with reddish or yellowish, the ventrals and pectorals of the eyed side are of the general ground tint, while their mates on the blind side are pure white. Small fish are apt to be paler and more blotched or mottled than large. Various color abnormalities have been recorded fish, for example, that are partially white on the eyed as well as on the blind side, or with the blind side yellow-edged –and it is not uncommon to see specimens dark blotched on the blind side. In fact, one-third of the fish caught near Providence, R. I., during the winter of 1897–98 were these "black bellies," as fishermen call them, but in 1900 the commissioners of fisheries of that State estimated them as forming only 4 per cent of the catch, and since then none, or at most only an odd example, has been seen. In 1898 some fry artificially hatched from eggs of "black-bellied" flounders were released in Waquoit Bay, where this race was unknown, and in 1900 several "black bellies" 7 to 8 inches long (hence probably two years old) were taken there, suggesting that this color variety is hereditary.[73]

Winter flounders change color to suit their surroundings, for they are usually very dark on mud and pale on bright sand bottoms, but field experience suggests that they have less control over shade and pattern than the summer flounder.

Size.—The largest winter flounder on record is one 21 inches long by 17 inches broad mentioned by Storer; and although Welsh saw three of about 19½ inches weighing, respectively, 3¼, 3¾, and 4 pounds, caught near Boon Island in April, 1913, fish longer than 18 inches or heavier than 3 pounds are unusual, the general run of adults caught inshore being from 12 to 15 inches in length and 1½ to 2 pounds in weight.

General range.—Shoal water along the Atlantic coast of North America, from northern Labrador to Georgia.

Occurrence in the Gulf of Maine.—This is the commonest shoal-water flounder of the Gulf of Maine, there being no bay or harbor in Nova Scotia, New Brunswick, or New England where it is not to be caught; and our experience goes to show that Huntsman's (1922a, p. 70) description of it as "very abundant everywhere in shallow water and at moderate depths" in the Bay of Fundy, and Storer's statement that it is the most common flatfish in Massachusetts waters, apply equally to the entire coast line of the Gulf, so much so that it would be tedious to give the very considerable list of localities whence it has been recorded.

[72] Bumpus. American Naturalist, Vol. XXXII, 1898, pp. 407–412.

[73] Bulletin, United States Fish Commission, Vol. XIX, 1899 (1901), pp. 305–306.

Habits.—This flounder is resident the year round wherever it is found north of Cape Cod, except that in very shallow estuaries which are largely laid bare to the sun at every tide (Duxbury Bay and Barnstable Harbor, for instance) the flounders move out or into the deeper channels during the heat of the summer, to return in the autumn, and again desert the ice-bound flats in the winter, to reappear there in spring. Winter flounders sometimes perish by thousands in very hot spells of summer weather [74] in the shallow bays of Long Island, but we have never heard of this happening in the Gulf of Maine where cooler water is always close at hand. On the other hand they may succumb to anchor ice in winter if caught in very shoal water in a severe freeze, for dead "flounders" of one sort or another are sometimes reported in such locations after unusually severe weather, and observations at Woods Hole have shown that temperatures near freezing (say 32° to 29°) drive them down into slightly warmer water. This migration of flounders out to sea in summer and back again in winter is more characteristic and regular south of Cape Cod, where the coastal waters are warmer (hence the common name "winter flounders"), than in the Gulf of Maine east of Cape Elizabeth, where they are to be found in abundance in most harbors and shoal locations generally all summer, either to remain over winter or to move out, according to local conditions of temperature. Apart from these bathic migrations (which in any case extend over short distances only) this is one of the most stationary of our fishes.

In the shoal waters of Great South Bay on Long Island, N. Y., Bean (1903, p. 778) describes the winter flounder as undergoing a "partial hibernation in the mud in winter," but as Breder has pointed out,[75] this is probably an error, the failure of the hook-and-line fishermen to take them in midwinter simply reflecting the fact that they will not bite at that season, winter being the spawning period when winter flounders fast as so many other fishes do. Experience at the Boothbay and Woods Hole hatcheries, with the results of the trawl fishery (p. 507), proves that they are as active in winter as in summer both north and south of Cape Cod.

Depth.—Tide mark, high or low according to the stage of the tide, is the upper limit for this flounder. It even runs up into brackish water in river mouths, but never, we believe, into fresh water. Its lower limit can not be stated definitely. It is certainly plentiful at 10 to 20 fathoms in Cape Cod Bay and on Stellwagen Bank, while the gill-netters take a considerable number of very large ones at about this same depth about Boon Island. According to general report, however, few, if any, are caught deeper than this in the inner parts of the Gulf except in the Bay of Fundy, where they are taken on soft bottoms down to 30 to 50 fathoms. The flounder of this type, which is caught down to 70 fathoms on Georges Bank, is now considered a separate, if closely allied, species, hence is treated separately (p. 507). Usually the smaller fish live shoalest and the larger ones deeper, but we have so often seen large flounders caught in only a few feet of water that no general rule can be laid down. The young fry are found chiefly in the shallows.

[74] Nichols (Copeia, March 19, 1918, No. 55, pp. 37–39) describes such an occurrence.

[75] Bulletin, United States Bureau of Fisheries, Vol. XXXVIII, 1921–22 (1923), p. 313.

This flatfish is catholic in its choice of bottoms. Perhaps most are caught on mud, especially when broken by patches of eelgrass, but it is common enough on sand and clay, and even on pebbly and gravelly ground. On soft bottom it usually lies buried, all but its eyes, working itself down into the mud almost instantly when it settles from swimming. Flounders that live on the flats usually lie motionless over the low tide to become more active on the flood when they scatter in search of food.

Winter flounders keep near the bottom. We have never heard of them coming up to the surface as the summer flounder so often does (p. 493), but though they spend most of their time lying motionless they can dash for a few yards with surprising rapidity, to snap up any luckless shrimp or other victim that comes within reach, or to snatch a bait, as any one may see who will take the trouble to watch them on the flats on a calm day. It is in this manner and not by rooting in the sand that they usually feed.

Food.—According to Sullivan [76] diatoms are the first food taken after the yolk of the larval flounder is absorbed. A little later they begin preying on the smaller Crustacea, and Sullivan invariably found isopods in the stomachs of fry just past their metamorphosis. A series of young flounders 1 to 4½ inches long from Casco Bay were found by Welsh to have fed as follows, mentioning the major items only: Crustaceans, chiefly isopods with lesser amounts of copepods, amphipods, crabs, and shrimps, 36 per cent; worms, 39 per cent; mollusks, only 2 per cent; various unidentifiable material, 22 per cent. Linton [77] who examined about 398 young flounders of various sizes at Woods Hole, likewise found them feeding chiefly on amphipods and other small Crustacea, together with annelid worms, and his tables of stomach contents show an increase in ratio of mollusks to Crustacea as the fish grow. The adult winter flounder, like the dab (p. 498), is constrained by its small mouth to a diet of the smaller invertebrates and fish fry. Sometimes they are full of shrimps, amphipods, small crabs, or other crustaceans; sometimes of ascidians, bivalve or univalve mollusks (Linton says it seems that they often bite off clam siphons which protrude from the sand), bloodworms (Nereis), or other annelids. They also eat squid, holothurians, hydroids, and sometimes bits of seaweed, and occasionally they capture small fish. Examination of the stomachs of adults taken at Woods Hole in February, 1921, by C. M. Breder [78] showed that they cease feeding when about to spawn.

In spite of its small mouth the winter flounder bites clams very readily provided that bait and hook are not too large, and great numbers are caught thus in harbors all along the coast.

Rate of growth.—Judging from a large series from Casco Bay measured by Welsh, the fry of the previous winter grow to an average length of 1½ to 3¼ inches by August with an occasional specimen as long as 4 inches, and to about 2¼ to 3½ inches by September, while in January and February, when 1 year old, the winter flounders are 4 to 6 inches long off southern New England, which probably applies

[76] Transactions, American Fisheries Society, Vol. XLIV, 1914–15, No. 1, p. 135.
[77] Appendix IV, Report, United States Commissioner of Fisheries, 1921 (1922), pp. 3–14
[78] Bulletin, United States Bureau of Fisheries, Vol. XXXVIII, 1921–22 (1923), p. 311.

north of Cape Cod as well. Welsh also concluded from measurements gathered from various sources that they are 5 to 7½ inches at 2 years of age, 7½ to 9½ inches at 3 years, and 9½ to 10 inches long when 4 years old. Probably they mature sexually at 3 years, for most of the spawners are upwards of 8 inches long.

Breeding habits.—The winter flounder is a winter and early spring breeder, spawning from January to May, inclusive, in New England. South of Cape Cod and in the Massachusetts Bay region the season is at its height during February and March,[79] but is somewhat later along the coast of Maine, for spawning commences about March 1 near Boothbay and continues there until about May 10 or 15 with the chief production of eggs usually taking place from March 20 to April 20, according to information supplied by Capt. E. E. Hahn, superintendent of the Boothbay hatchery. This local difference in the spawning season is probably due to differences in the temperature of the water, and after the severe winter of 1922–23, when an unusual amount of ice formed and consequently when the vernal warming of the coastwise waters was slower than usual, Captain Hahn writes that "the fish were 10 to 15 days later in spawning than in any previous year, the first eggs being taken on March 24."

Spawning takes place on sandy bottoms in 1 to 3 fathoms of water and throughout the range of the fish including the Bay of Fundy, where Huntsman found its larvæ common near the mouths of estuaries. On the average individual females produce about 500,000 eggs annually, and nearly 1,500,000 have been taken from a large one of 3⅜ pounds weight. Spawning is at its height while the water is at its coldest for the year, this being about 32° to 35° in the Woods Hole region, about 32° to 37° at Gloucester, and 31° to 35° near Boothbay according to precise locality and depth. The major production of eggs takes place before the water has warmed above 38° with 40° as perhaps the maximum for any extensive spawning. Corresponding to the estuarine or at least the inshore location of the spawning grounds the salinity is likewise low, and the winter flounder is even known to spawn in brackish water. For instance breeding has been observed near Woods Hole in water as little saline as 11.43 per mille, and the maximum salinity in which winter flounder eggs are produced in the Gulf of Maine probably is not higher than 32.3 per mille. Winter flounders in the Woods Hole tanks (probably in nature too) spawn at night.[80]

This species is peculiar among our local flatfish (or those whose breeding habits are known) in the fact that its eggs are not buoyant but sink to the bottom, where they stick together in clusters, usually so closely massed that the individual eggs are forced into irregular outlines. They are 0.74 to 0.85 mm. in diameter. Newly shed eggs have no oil globule but some, if not all, develop one as incubation proceeds.[81] Incubation occupies 15 to 18 days at a temperature of 37° to 38°, which is about what they encounter in nature. The young larvæ, which are 3 to 3.5 mm. long at hatching, are marked by a broad vertical band of pigment cells dividing the post anal part of the body into two parts, a very characteristic feature, and the

[79] This species is artificially propagated in large numbers at Woods Hole, Gloucester, and Boothbay hatcheries with an output of 1,603,080,000 fry in 1920.

[80] Breder (Copeia, Jan. 25, 1922, No. 102, p. 3) describes the act of spawning.

[81] Breder. Bulletin, U. S. Bureau of Fisheries, Vol. XXXVIII, 1921–22 (1923), Fig. 274g.

end of the gut is also heavily pigmented. In water of about 39° the larva grows to 5 mm. in length, and the yolk is absorbed (fig. 258) in 12 to 14 days. In 5 to 7 weeks after hatching, at a length of about 6 mm., the vertical fin rays begin to appear and the left eye has moved upward until about half of it is visible above the dorsal outline of the head, while in larvæ of 8 mm. the whole left eye shows from the right side and the fins are fully formed. Metamorphosis goes forward so rapidly there-

FIG. 257.—Egg

FIG. 258.—Larva, 19 days old, 4.5 millimeters

FIG. 259.—Larva, 5 millimeter

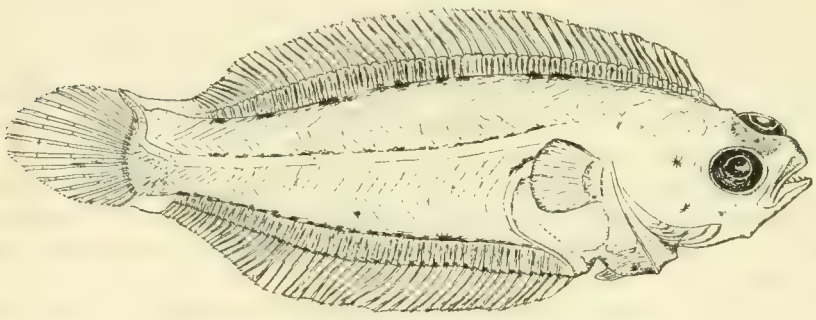

FIG. 260.—Larva, 8 millimeters

WINTER FLOUNDER (*Pseudopleuronectes americanus*)

after that within three days, according to Williams,[82] the left eye moves from this position to the right side of the head, the pigment fades from the blind side, the eyed side becomes uniformly pigmented, the little fish now lies and swims with the blind side down, and when only 8 to 9 mm. long its metamorphosis is complete.

[82] Bulletin, Museum of Comparative Zoology at Harvard College, Vol. XL, 1902–3, No. 1, pp. 1–58, pls. 1–5. See also Sullivan (Transactions, American Fisheries Society, Vol. XLIV, 1914–15, pp. 125–136, figs. 1–4) and Breder (Bulletin, U. S. Bureau of Fisheries, Vol. XXXVIII, 1921–22 (1923), p. 311).

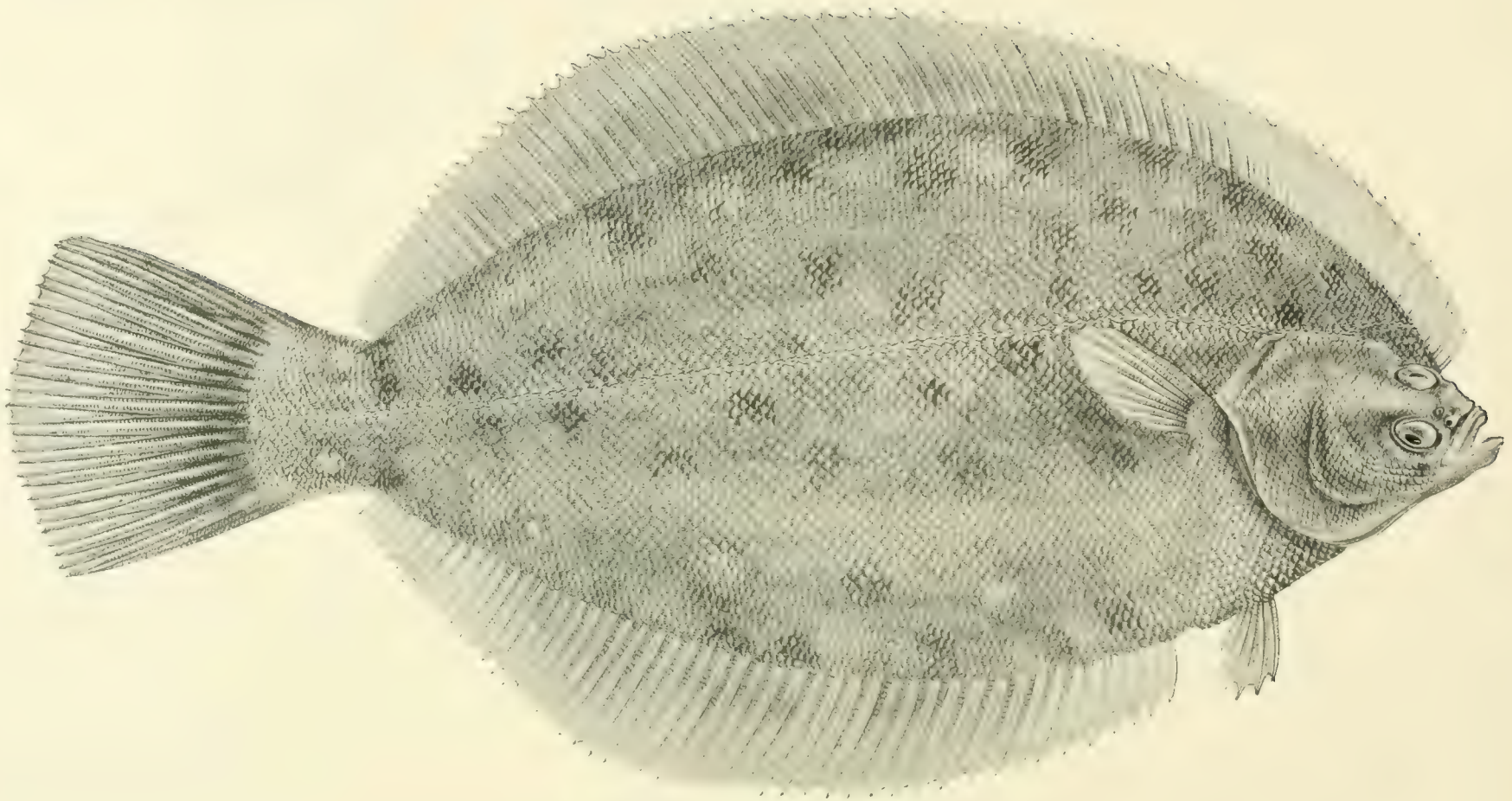

Fig. 261.—Georges Bank flounder (*Pseudopleuronectes dignabilis*)

The youngest larval stages are identifiable as winter flounders, up to the time the mouth is formed, by the pigment bar just mentioned; after the fin rays appear the small mouth separates them from any of the large-mouthed flounders; the short, deep body, combined with few fin rays, separate them from the witch; and the number of rays mark them off from the dab (p. 495). The winter flounder completes its metamorphosis at a smaller size than either of these other small-mouthed flatfish (pp. 508 and 511).

The rate of development of the larvæ is governed by temperature, occupying from about 2½ to about 3½ months, according to the data available, and the larvæ hatched later may catch up with the earlier ones before metamorphosis. Larvæ in their later stages have been taken in abundance in the tow nets at Woods Hole; but their habits in aquaria suggest that they are less at the mercy of tide and current than our other flatfishes, for they have been described as alternately swimming upward and then sinking and lying for a time on bottom instead of remaining constantly afloat and near the surface like the larvæ of most other flatfish and of the gadoids at a corresponding stage in development.[83]

Commercial importance.—Of late years this has come to be a very important fish commercially, and it is the best flavored as well as the thickest and meatiest of our smaller flatfish. Unfortunately we can not give the annual catch, all flounders being lumped together in the returns, but probably at least half of the three million and odd pounds of flatfish taken by the small-boat fishery of Massachusetts in 1908 were this species, and they form a majority of the catch along the Maine coast, which amounted to nearly 500,000 pounds in 1919. Flounders are caught in trawls, seines, and weirs. They are speared in great numbers on the flats in winter, and flounder fishing with hand lines goes on in the estuaries all along the shores of the Gulf.

172. **Georges Bank flounder** (*Pseudopleuronectes dignabilis* Kendall)

LEMON SOLE

Description.—This flatfish was first brought to scientific attention in 1912 when specimens were received by the Bureau of Fisheries. To all intents it is a magnified winter flounder, averaging something over 20 inches long, with more fin rays (68 to 73 dorsal and 50 to 54 anal), relatively shorter head, and as a rule is of a light yellowish brown color washed with lemon yellow, more or less dark blotched and mottled, and not of the dull reddish or slaty brown so characteristic of the winter flounder. Kendall (1912, p. 391), in his description, to which we refer the reader for a full account of the variable color of this fish, also mentions differences in the number of gill rakers and in the number and arrangement of the teeth, but whether these differences will prove constant or whether this species is merely a large brilliantly colored race of the winter flounder can be decided only by a study of many specimens of various sizes.

[83] Three larvæ taken in the Gulf in July, 1912, and provisionally identified by Welsh as this species, probably belonged to some other flounder, for it is most unlikely that any winter flounders would be so small (only 6.5 mm. long) in midsummer.

General range and occurrence in the Gulf of Maine.—This flounder is known only on Georges Bank and it was overlooked there until very recently, for due to its small mouth it is seldom caught on the large hooks used by cod and haddock hand-line and line-trawl fishermen, but when the otter trawlers commenced operations on the bank they began at once to take large numbers of these "soles" or "lemon soles," as they are usually dubbed by fishermen. They are most plentiful on the shoaler parts of the bank, only odd ones being taken below 40 fathoms, with 70 fathoms as the deepest definite record for the species. More or less "soles" are brought in on every otter-trawling trip (anywhere from a few hundred to several thousand fish, according to depth and precise location on the bank), and during the summer of 1913 these "soles" constituted about 4 per cent in number of all the fish caught by the several otter trawlers that carried investigators from the Bureau of Fisheries, about 600,000 pounds being marketed. Exact figures of the present-day landings can not be given, "soles" not being separated from other flatfish in the returns, but they certainly constituted the majority of the 1,500,000 pounds of flounders landed in Boston and Gloucester from Georges Bank in 1919, which gives some measure of their local abundance.

Habits.—Nothing is known of the habits of this fish except the depth of water in which it lives, that it spawns in April and May as proven by the capture of ripe fish, and that it feeds largely on hydroids and to a less extent on small crabs and other invertebrates. Presumably its manner of life parallels that of the winter flounder, and its eggs, like those of the latter, will probably prove to be demersal, not buoyant.

173. **Smooth flounder** (*Liopsetta putnami* Gill)

SMOOTHBACK FLOUNDER; EELBACK; FOOLFISH; CHRISTMAS FLOUNDER; PLAICE

Jordan and Evermann, 1896–1900, p. 2650.

Description.—This flatfish is right-handed (eyes on the right side) and small-mouthed like the winter flounder, dab, and witch, and it closely resembles the former (with which it is often caught) in its general outline and in the considerable thickness of its body, but is distinguishable by the fact that the skin of its head between the eyes is smooth and scaleless. Females are more easily recognized than males, their bodies being smooth to the touch on both sides. Males are nearly as rough skinned on the eyed side (except between the eyes) as winter flounders, but they have much longer pectoral fins than the latter. Both sexes have fewer fin rays (only 65 to 67 dorsal and 35 to 40 anal), while the caudal fin of the smooth flounder is narrower and more rounded than that of the winter flounder.

The smooth flounder can always be separated from the dab by the facts that its very prominent lateral line is straight, not arched, the dorsal (left) profile of its head is straight, not concave, and its fin rays are fewer. It has little more than half as many dorsal and anal rays as the witch, and the facts that its long fins are highest midway of the body and tapering toward the head and tail, whereas they

are nearly uniform in height from end to end in the witch, and that it lacks the mucus pits so characteristic of the blind side of the head of the latter, are reliable field marks in the separation of these two species.

The smooth flounder is peculiar among our local flatfish for its sexual dimorphism. Besides the difference in the scales of the two sexes noted above, the pectorals on the eyed side are longer (about four-fifths as long as the head) and more pointed in the rough-backed males than in the smooth-backed females.

Color.—The "smoothback" varies from grayish to dark muddy or slaty brown or almost black above, either uniform or variously mottled with a darker shade of the same tint, with the dorsal, anal, and caudal fins of the general ground color. In specimens we have examined these fins were mottled, but Storer described them as black spotted. The blind side is white.

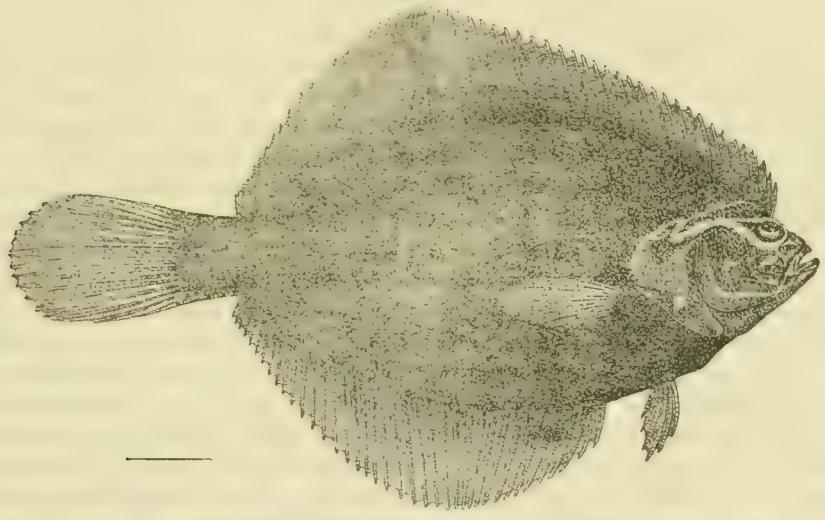

FIG. 262.—Smooth flounder (*Liopsetta putnami*)

Size.—This is the smallest flounder common in the Gulf of Maine, growing to a maximum length of only about a foot and to a weight of about a pound and a half.

General range.—The distribution of the smooth flounder in American waters is Arctic-boreal. It is definitely recorded from as far north as Ungava Bay in Hudson Straits, hence no doubt occurs along the Atlantic coast of Labrador, also from the Gulf of St. Lawrence, and there are specimens from St. Anthonys on the eastern coast of northern Newfoundland in the Museum of Comparative Zoology. We find no record of it on the outer coast of Nova Scotia between Cape Breton and Cape Sable, but probably it has been overlooked there, being widespread in the Gulf of Maine, as detailed below. It is known as far south as Providence, R. I. Its range is probably continuous with that of its Polar relative (*L. glacialis*) of the Arctic coasts of North America and Siberia. Indeed, it is a question whether any valid distinction can be drawn between the two.

Occurrence in the Gulf of Maine.—So far as is known this flatfish is confined to the close vicinity of the coast, occurring chiefly in the mouths of estuaries or rivers and in sheltered bays or harbors. In such locations it is to be found locally all along the shores of the Gulf from the Bay of Fundy to the northern shores of Massachusetts Bay. The Gulf of Maine localities whence it has been definitely reported in numbers or recorded in print are the shores of the Bay of Fundy generally, Bucksport at the mouth of the Penobscot River, Belfast, Penobscot Bay, Casco Bay, Portland, Salem Harbor, and Boston Harbor. Apparently the latter is the southern limit to its regular occurrence for it is unknown in Cape Cod Bay or along Cape Cod, so far as we can learn, or in the Woods Hole region, though a stray now in the collection of the Museum of Comparative Zoology was caught at Providence, R. I. This flatfish is often confounded with the winter flounder, and it has so often been found in various markets among the latter that it is no doubt far commoner all along the coast of northern New England than is generally appreciated.

The smooth flounder is very abundant in summer in Casco Bay and in estuaries of the Bay of Fundy such as the mouths of the St. Croix and Annapolis Rivers, which no doubt applies equally to the intervening coast line, but it is said that in Massachusetts Bay it comes into harbors only in autumn and winter;[84] nor would such a local difference be surprising in the case of a cold-water fish, which might well be driven out off the flats into slightly deeper water by summer heat in the southern and western parts of the Gulf but not in the northern and eastern.

Huntsman (notes) describes the local distribution of this flounder in the Annapolis River mouth and basin as depending more on the type of bottom than on the precise temperature, for although the water of the former was as warm as 57° he found the smooth flounder much more plentiful on its soft mud bottom than the winter flounder, but the latter alone on the harder bottom of the basin although the temperature (48.5° to 51°) was lower there. This preference for soft bottom was so strong that while a seine haul on soft mud yielded 23 smooth to 4 winter flounders another only 100 yards or so distant but on harder bottom brought in only 3 of the former to 189 of the latter. In localities where the bottom is uniformly muddy, however, the two species are often found side by side. So far as known the smooth flounder is confined to shallow water, probably with 15 fathoms as about its lower limit in the Gulf of Maine and 3 to 5 fathoms the zone of greatest abundance for it. Tide mark is its upper barrier.

Food.—Little is known of the life of this species, but its small mouth suggests a diet similar to that of the winter flounder, and Dr. W. C. Kendall found that young fry 3 to 4 inches long from Casco Bay had been feeding chiefly on small crabs, shrimp, unidentified crustaceans, and polychæte worms.

Breeding habits.—Winter is the breeding season, females nearly ripe having been taken in Salem Harbor in December and spent fish at Bucksport the first week in March, which corroborates fishermen's reports of more than half a century ago that it comes into Salem Harbor to breed at about Christmas time. It is not known whether the eggs sink or are buoyant, nor have its larvæ been seen.

Commercial importance.—This is an excellent table fish for its size and as sweet-meated and thick-bodied as the winter flounder.

[84] Our experiences corroborate this to the extent that we have never seen it there in summer

174. Witch flounder (*Glyptocephalus cynoglossus* Linnæus)

FLUKE; CRAIG FLUKE; SOLE; POLE FLOUNDER

Jordan and Evermann, 1896–1900, p. 2657.

Description.—The witch is right-handed (eyes and guts on the right hand as the fish lies) and small-mouthed like the winter and smooth flounders and the dab, but there is little danger of confusing it with any of these as its fin rays are so much more numerous, its body more elongate, its head much smaller, and the large open mucus pits on the blind side of the head are so apparent. It is two and one-half to three times as long as "broad," elliptical in outline, very thin-bodied, with head so short that it only occupies about one-fifth of the total body length, and it has a very small mouth. The dorsal (left) profile of its head is convex. There are 100 to 115 dorsal and 87 to 100 anal rays, and the anal fin is preceded by a short, sharp spine pointing forward, a prolongation of the postabdominal bone. The two long fins are of about uniform height throughout most of their length, narrowing gradually toward the head and tail. The pectoral fins and the ventrals are alike on the two sides, or nearly so, while the caudal fin is much smaller relatively than that of the dab, winter flounder, or smooth flounder, though similarly rounded. The lateral line is usually straight, but occasionally somewhat arched abreast the pectoral fin. The jaw teeth are small, incisorlike, and in a single series. There are about 12 open mucus pits or depressions on the blind side of the head, and less obvious ones on the eyed side also. The whole body and head (except the tip of the snout and the lower jaw) are scaly, but the scales are smooth to the touch making the witch as slippery to hold as a female smooth flounder (p. 508).

Color.—By all accounts (and the fish we have seen are in line with this) the witch is less variable in color than most flounders. Usually it is brownish or russet gray on the eyed side, either uniform or with darker transverse bars, with the vertical fins of the general body hue tinted or tinged with violet and either plain or spotted, while the pectoral fin membrane on the eyed side is dusky or even black, a feature diagnostic of this species. The lower (blind) side is white and more or less dotted with minute dark points.

Size.—The maximum length is about 25 inches, but while fish of 23 or 24 inches and weighing about 4 pounds are not uncommon the general run of those caught is only about 12 to 20 inches.

The witch probably grows to 40 or 50 mm. within 4 to 6 months from the time of hatching—that is, by autumn or early winter, as detailed hereafter (p. 515). Fry of 65 to 108 mm., such as we have trawled in July, are no doubt in their second summer, their size depending on how early in the previous summer they were hatched. The later growth has not been studied so far as we are aware.

General range.—Moderately deep water on both sides of the North Atlantic. Its European range is from northern Norway and Iceland south to the west coast of France, while in American waters it is known from the south coast of Newfoundland, from the Gulf of St. Lawrence,[85] from the Laurentian Channel, along outer Nova Scotia and the Scotian Banks, in the Gulf of Maine, including the offshore banks and their seaward slopes, and along the continental slope as far south as the latitude of Delaware Bay.

[85] Huntsman, 1918a, p. 63.

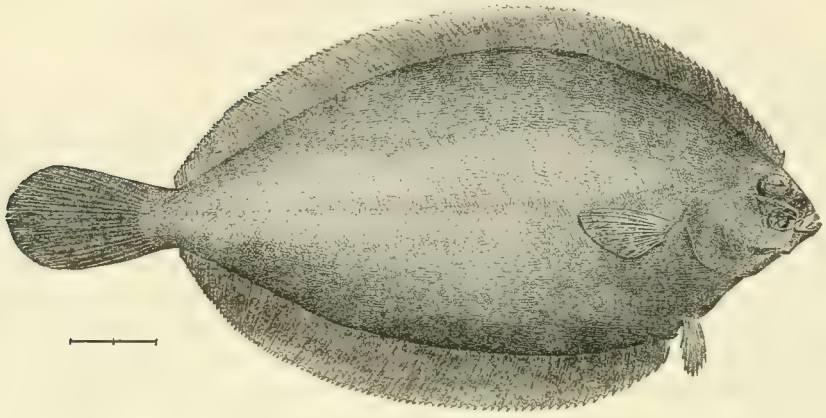

FIG. 263.—Adult

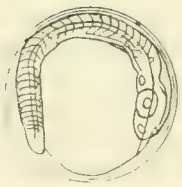

FIG. 264.—Egg (European). After Cunningham

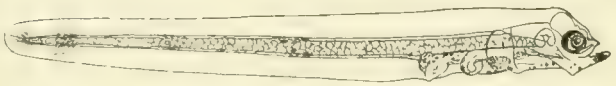

FIG. 265.—Larva (European, 10 days old, 5.6 millimeters. After Holt

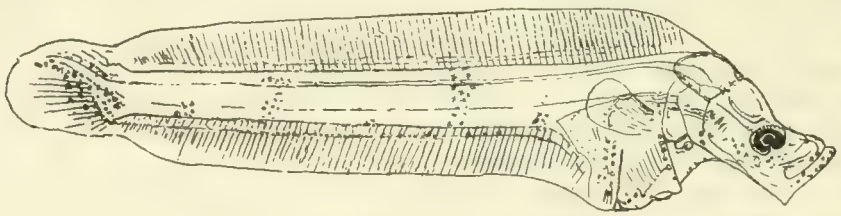

FIG. 266.—Larva (European), 16 millimeters. After Kyle

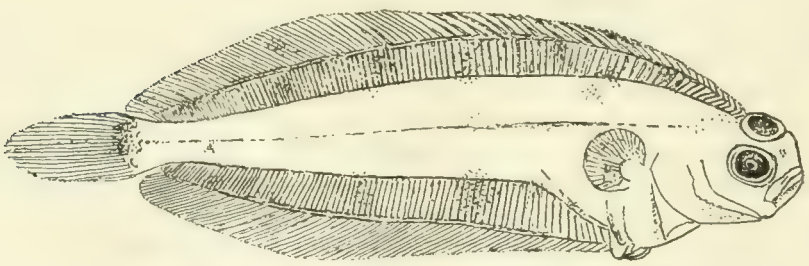

FIG. 267.—Larva (European), 42 millimeters. Smallest bottom stage. After Petersen

WITCH FLOUNDER (*Glyptocephalus cynoglossus*)

Occurrence in the Gulf of Maine.—The distribution of this flounder in the Gulf is governed by the fact that while it has occasionally been taken close inshore (for example in weirs near Eastport [86] and in Passamaquoddy Bay) it is characteristically a deep-water fish, hardly ever coming above 10 or 15 fathoms. Owing to the facts that its mouth is so small that it can not take a cod or even a haddock hook and that it almost never strays up into the shallows where cunner and flounder fishermen might catch it, its very existence in the Gulf was unguessed by Massachusetts fishermen until 1877, when the United States Bureau of Fisheries caught numbers of witches in a beam trawl in the deeper parts of Massachusetts Bay. Since that time it has been definitely recorded from St. Mary Bay on the Scotian side of the Gulf, in the Bay of Fundy and its tributaries (where Huntsman describes it as taken very generally if not in any great numbers below 15 fathoms), at Eastport, off Monhegan, off Seguin Island, off Cape Porpoise, near the Isles of Shoals (where Welsh saw a few taken from the gill nets set in about 25 fathoms in April, 1913), near Gloucester, at various localities in the deeper parts of Massachusetts Bay, and from the western basin. We have trawled it on the *Grampus* off Monhegan, near Seguin, in Ipswich Bay, near Gloucester, and off the mouth of Boston Harbor in depths ranging from 22 to 60 fathoms. It has been taken in the Eastern Channel and on the slope to the southeast. It also occurs very generally on Georges Bank, where Welsh saw many taken in the otter trawl, and no doubt it inhabits Browns Bank also. This is enough to show that the witch is to be expected anywhere in the Gulf in water deeper than 15 to 20 fathoms if the bottom be suitable, which means locally all around the coastal belt and on the smoother parts of all the deeper fishing grounds, but we have yet to learn how widespread it is in the deep basin of the Gulf. But though its existence there is proven and though it has been taken as deep as 858 fathoms [87] on the continental slope it is probable that most of the local stock lives between 25 and 100 fathoms. Witches are caught most abundantly on soft bottom such as fine muddy sand, clay, or even mud. They are said to frequent hard reefs in Scandinavian waters, but this does not seem to be the case in the Gulf of Maine, though they are common there on the smooth ground between rocky patches.

When adult the witch is as stationary as most other flounders, to be caught the year round wherever it occurs, but its pelagic larvæ are at the mercy of the current for a long period (p. 515).

In the Gulf of Maine the witch occurs in temperatures ranging from about 35° or 38° (late winter and early spring) to 45° or 48° (late summer and early autumn), according to precise locality and depth, and apparently it is never found in any numbers in water warmer than 50°, but we hesitate to propose high temperature as the factor barring it from shoal water because there is no evidence of its moving inshore in winter when this would not operate. In the Gulf of St. Lawrence it occurs in the icy cold (32°) water on the banks as well as in the slightly higher temperatures (39° to 42°) of the deep channels.[88]

[86] Reported by Gill (1873, p. 360) as *G. acadianus*.

[87] It was trawled down to 858 fathoms by the *Albatross*. Goode and Bean (1896) give a long list of deep-water localities for the witch off southern New England.

[88] According to Huntsman (1918a, p. 63).

Food.—This is an invertebrate eater like other small-mouthed flounders, European experience pointing to small crustaceans, starfish, small mollusks, and worms as its chief diet.[89] It is not known to eat fish and seldom takes a bait.

Breeding habits.—In European waters this flatfish spawns from late April until September, and while so far as we know ripe fish have not been reported from the Gulf of Maine our captures of eggs, almost certainly of this species, in July and August are evidence that it is equally a summer spawner there. The fact that we have taken larvæ as long as 20 to 23 mm. by the first week in July (p. 515) and others as small as 9 or 10 mm. as late as mid-October also indicates that spawning commences as early in the Gulf and endures as late there as on the other side of the Atlantic. Probably July and August see the height of production. Thus its breeding season overlaps that of the haddock (p. 442). At present our only positive egg records are at the mouth of Massachusetts Bay and off Penobscot Bay, but probably it breeds all along the coastal zone from Cape Cod to Mount Desert and off the west coast of Nova Scotia as well. Apparently it does not breed successfully in the Bay of Fundy, for neither its eggs nor its larvæ have been found there. No definite evidence has yet been obtained by capture either of ripe fish or of eggs or larvæ in the tow net that it spawns on Georges Bank or on Browns, though it probably does so. Both the Gulf of St. Lawrence and the waters off the south coast of Newfoundland likewise serve as breeding grounds, for larvæ less than 10 mm. long were taken in both these regions by the Canadian Fisheries Expedition in 1915, but there is no evidence that the witch spawns west of Cape Cod.

The witch necessarily spawns through a wide range of both temperature and salinity, breeding as it does over so protracted a period and over so many degrees of latitude. In the Gulf of Maine its eggs are shed in temperatures ranging from 39° to 41° at the beginning of the season to from 43° to 48° in midsummer, but, being buoyant (p. 515), the temperature in which their development takes place and which thus governs the success of reproduction may be considerably higher than that of the deep water in which the spawning fish lie. In fact it is doubtful if any eggs develop in water as cold as 42° or 43° in the Gulf, though they may be spawned in lower temperatures, nor is there any reason to suppose that witch eggs spawned in the icy cold bottom water off Newfoundland or in the Gulf of St. Lawrence actually develop at lower temperatures than those produced in the Gulf of Maine, for the surface stratum to which they rise immediately after they are shed is comparatively warm (upward of 45°) during the spawning season. Experiment has shown that incubation proceeds normally and rapidly at 46° to 49°, hence, this is evidently a favorable figure. It appears from this that no part of the Gulf of Maine is cold enough in summer to hinder the successful reproduction of the witch, hence its failure to breed in the Bay of Fundy is due to some other cause. Our captures of eggs and of newly hatched larvæ near the surface in July prove that incubation can take place successfully in water at least as warm as 50° to 55°, but the upper limit to normal development can not be stated from the evidence yet in hand, for with a temperature gradient as steep as it is over most of the Gulf of Maine in

[89] No witch stomachs have been examined in the Gulf of Maine.

summer a difference of only a few fathoms in the depth at which the eggs or young larvæ are suspended means a difference of several degrees of temperature.

The eggs are buoyant, spherical, transparent, with narrow perivitelline space (in plaice eggs, which overlap them in dimensions, the perivitelline space is broad), without oil globule, and 1.07 to 1.25 mm. in diameter. As noted elsewhere (pp. 429 and 443), there is danger of confusing newly spawned witch eggs with those of cod or haddock, for they overlap in size and in season; but identity as witch or as gadoid is easily recognizable after a few days' incubation, for black pigment is to be seen in the latter soon after the embryo is visible as such but does not appear in the witch until after hatching, such embryonic pigment as is visible in the egg being of a faint yellowish color.

Incubation occupies 7 to 8 days at temperatures varying from 46° to 49° F., and the newly hatched larva is about 4.9 mm. long with larger yolk sac than our other flatfishes. Within a few days after hatching, when the larva is 5 to 6 mm. long, the yellow and black pigment becomes aggregated into 5 transverse bands on body, yolk (now much reduced in size), and fin fold—that is, 1 at the region of the pectoral fin, 1 at the vent, and 3 on the long slender post-anal part of the trunk. The yolk is entirely absorbed in about 10 days after hatching; at a length of 15 mm. the caudal rays have begun to appear, at 21 mm. those of the vertical fins are well advanced, and at about 30 mm. they are complete in their final number. Up to this stage the eyes are still symmetrical or nearly so, but in larvæ of about 40 mm. the left eye has moved to the dorsal surface of the head, while at a length of 40 to 50 mm. the migration of the eye is complete and the young fish takes to the bottom.

The witch is perhaps the most easily recognizable of Gulf of Maine flatfishes throughout its larval stage. Prior to the appearance of the caudal rays the transverse pigment bars are diagnostic, and thereafter it is characterized by the curiously concave ventral profile of the throat region and by its comparatively long slender trunk, while the great number of dorsal and anal rays, coupled with the small mouth, make identification easy after the fins are formed. The witch grows to a larger size before metamorphosis than any other of the right-handed, small-mouthed species found in the Gulf of Maine.

Measurements of the young, American as well as European, show that the pelagic stage lasts from four to six months. The result of their remaining near the surface so long, combined with the protracted spawning season, is that larvæ of various sizes may be towed throughout the summer in the Gulf of Maine, as appears from the following table of our catches on the *Grampus:*

Date	Number of larvæ	Length in millimeters	Date	Number of larvæ	Length in millimeters
July 7, 1915	109	8 to 23.5	August 15, 1913	3	18.5 to 37.5
July 8, 1913	19	8.5 to 21.5	August 24, 1912	6	10 to 18
July 9, 1913	1	14	August 25, 1914	19	10 to 19
July 19, 1916	100+	5 to 19.	August 26, 1913	2	8 and 14
July 22, 1912	1	9.5	August 29, 1916	100+	5 to 19
July 24, 1912	2	8.5 and 16.5	August 31, 1912	20+	9 to 16.5
August 5, 1913	27	5.5 to 12.5	September 29, 1915	22	10 to 14
August 9, 1913	7	10 to 23	October 18, 1915	1	9.5
August 14, 1912	1	18.5	November 1, 1916	20+	29.5 to 50

All these records, like those for other flatfish and gadoids, are concentrated in the southwestern part of the Gulf, which must be an important nursery for the witch (fig. 255).

With its larvæ so plentiful and easily recognized, and its pelagic stage so long, this species would no doubt prove an especially favorable object for the study of larval migrations. We may note in passing that the presence of young fry at all stages from immediately after their metamorphosis (that is, 4 to 6 months old) in the Bay of Fundy, where few or none are hatched, points to an immigration of the late larvæ or of the youngest fry at about the time they take to the bottom.

Commercial importance.—The witch is of little commercial importance and no record is kept of the catch either of the otter trawlers or of the shore fisheries. In fact few fishermen distinguish it from other flounders, consequently there is no available basis for comparing its local abundance in the Gulf of Maine with that of other species. It is certainly plentiful enough in Massachusetts Bay to yield a considerable catch when demand arises, for as much as 500 pounds have been caught there in a 15 to 20 minute drag of a small beam trawl, and we took 48 good-sized ones in one drag in Ipswich Bay from the *Grampus* in July, 1912.

The introduction of the witch into American markets is only a matter of time, for it is an excellent table fish, perhaps the best of all our flatfishes in flavor, while for so thin a flounder the bases of its fins are provided with surprisingly large amounts of gelatinous fat of the sort for which the European turbot is famed.

The otter or beam trawl is the only gear adapted to the capture of the witch flounder on a commercial scale.

175. **Sand flounder** (*Lophopsetta maculata* Mitchill)

SPOTTED FLOUNDER; WINDOWPANE; NEW YORK PLAICE; SAND DAB; SPOTTED TURBOT; ENGLISH TURBOT; WATERY FLOUNDER

Jordan and Evermann, 1896–1900, p. 2660.

Description.—This is the closest North American relative of the European turbot and brill. It is left-handed (eyes and guts at the left) and large-mouthed like the summer and four-spotted flounders but is readily separable from them by the outlines of its ventral fins. In all other Gulf of Maine flatfish except the hogchoker (p. 522) these are narrow at the base and widen toward the tip, but in the sand flounder they are as wide at the base as at the tip, each simulating a detached segment of the anal. Furthermore the two ventrals are not alike either in location or in size, the left-hand (upper) fin, which is the longer of the pair, being practically a continuation of the anal so far as external appearance goes, whereas the right-hand (lower) ventral is situated a short distance up the right side of the throat. The general appearance of the dorsal fin is no less diagnostic, for its first 10 or 12 rays are not only free from the fin membrane over the outer half of their length but are branched, so that they form a conspicuous fringe which is without parallel among Gulf of Maine flounders. Furthermore the sand flounder is more nearly round in outline than any of the other local flatfishes (only about one and one-half times as long as broad) and so thin that its body is translucent when held up to the

light. Its pectorals, too, are longer than in the other left-handed species, its caudal fin is more rounded, and its teeth much smaller, although the gape is as wide. The dorsal (65 to 67 rays) and anal (51 or 52 rays) fins both taper toward head and tail, while both are noticeably thick and fleshy at the base, and there is no free anal spine. The pectoral on the eyed side is longer and more pointed than its mate on the blind side, the scales are smooth to the touch, and the lateral line is bowed abreast of the pectoral fin.

Color.—The sand flounder varies less in color than most shoal-water flatfish, the general ground tint of the eyed side (both as described by previous authors and in those we have seen) being some shade of pale, rather translucent, greenish olive or slightly reddish or slaty brown, more or less mottled with dark and light and usually, if not always, dotted with many small brown spots of irregular outline.

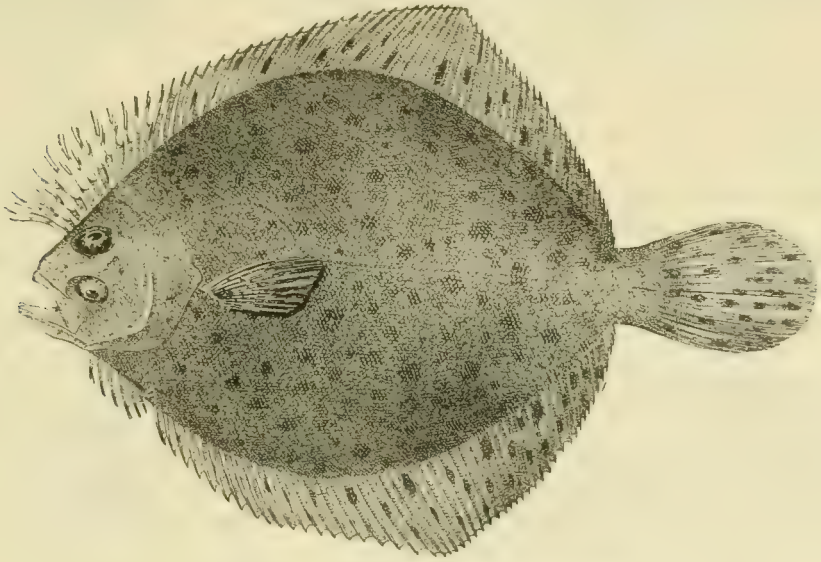

FIG. 268.—Sand flounder (*Lophopsetta maculata*)

Some fish are also marked on the body and on the bases of the vertical and caudal fins with white spots of varying number and size, but others lack these spots. The dorsal, anal, and caudal fins are of the general body tint more or less mottled with darker, while the pectoral of the eyed side is dark crossbarred or speckled. The blind side is white.

Size.—The maximum length is 18 inches and the weight 2 pounds. The largest we have seen (from Waquoit on the southern shore of Massachusetts), were about 15 inches long, but in general adult fish are only about 10 to 12 inches in length.

General range.—Shoal water off the coast of eastern North America from the Gulf of St. Lawrence to South Carolina. It is most abundant west and south of Cape Cod, north and east of which it is nowhere numerous, and is confined to favorable localities.

Occurrence in the Gulf of Maine.—This flounder is comparatively rare in the Gulf of Maine. Dr. W. C. Kendall found it at Monomoy, Storer found it at Provincetown, where he saw a considerable number in shoal water, and it is reported from North Truro, Gloucester Harbor, where a considerable number were collected in 1878 (Welsh found it not uncommon there in 1916), and at Milk Island near by, but we can not learn that it is taken in numbers anywhere in the Massachusetts Bay region. I have never seen it at Cohasset nor are local fishermen sufficiently familiar with it to throw any light on the subject. It has never been recorded between Cape Ann and Casco Bay, nor did Welsh see it taken there by the gillnetters during the spring of 1913; and while it has been reported repeatedly and at several localities in Casco Bay, which seems to be a local center of abundance, it can not be common along the eastern Maine coast or on the New Brunswick side of the Bay of Fundy, the only records from this stretch of coast line being from Bucksport, Eastport, and Passamaquoddy Bay, where one was taken in 1880 and another in 1912. Minas Channel on the Scotian side is evidently a center of abundance like Casco Bay, for Leim found it common there.[90] Huntsman also reports it in St. Mary Bay, though we have found no other record of it along the western coast of Nova Scotia. In June, 1912, Welsh saw this flounder taken in the otter trawls on Georges Bank, beyond which nothing is known of it on the offshore fishing grounds. The sand flounder is much more plentiful west of Cape Cod than it is anywhere in the Gulf of Maine, and it is common everywhere on sand bottoms in the Woods Hole region.

The sand flounder is a shoal-water fish, living from close below tide mark down to 30 or 40 fathoms, at which depth Welsh saw it taken on Georges Bank, but 17[91] to 20 fathoms probably marks its lower limit in the coastal zone north of Cape Cod. It is caught chiefly on sand bottom off southern New England and southward, as its name implies, but its comparative abundance in Casco Bay and in Minas Channel shows that it also frequents softer and muddier ground in the Gulf of Maine. This species is a year-round resident off the southern New England coast, which probably applies to it in the Gulf of Maine also.

Food.—The large mouth suggests that this species, like the summer flounder, is largely a fish eater, and hake, herring, launce, and silversides have been found in the stomachs of sand flounders caught at Woods Hole. It likewise feeds as indiscriminately on small invertebrates as does the winter flounder, Vinal Edwards having noted annelid worms, shrimps, crabs, squid, mollusks, ascidians, and even seaweed in sand-flounder stomachs, while Welsh remarks in his field notes that fish caught off Atlantic City, N. J., were full of schizopod shrimps and of them alone.

Rate of growth. It seems that the sand flounder passes through its larval stage more rapidly than do most flatfish, for many fry with the migration of the eye completed have been taken at Woods Hole only one to two months after spawning commences there. One kept in an aquarium there by Williams[92] grew from 10 mm. to 22 mm. in length in 11 days, and in Rhode Island waters, according to

[90] Huntsman, 1922a, p. 70.

[91] It is common down to this depth near Woods Hole.

[92] Bulletin, Museum of Comparative Zoology at Harvard College, Vol. XL, 1902-3, p. 3.

Tracy (1910, p. 166), the fry are 2 to 3 inches long in July and 4 inches and upward in December. Measurements made by Welsh off the New Jersey coast indicated an average length of about 6 to 9 inches by the end of the second summer and 10 to 12 inches the third summer when the fish are mature.

Migrations.—Owing to the brevity of its pelagic stage, already remarked (p. 518), its involuntary downstream migrations are necessarily short and consequently the chance of dispersal by this means is slight. As there is no reason to suppose that

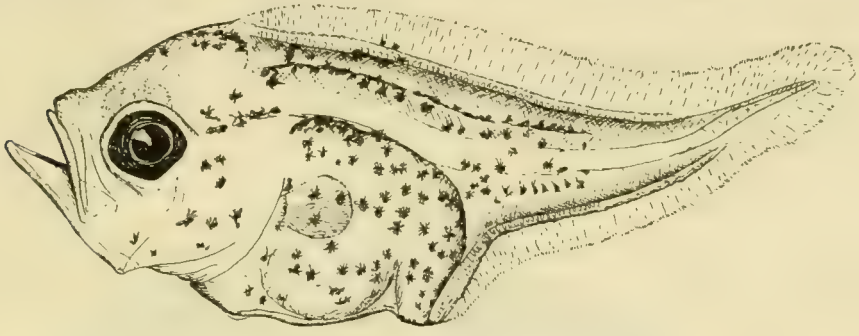

FIG. 269.—Larva, 5.5 millimeters

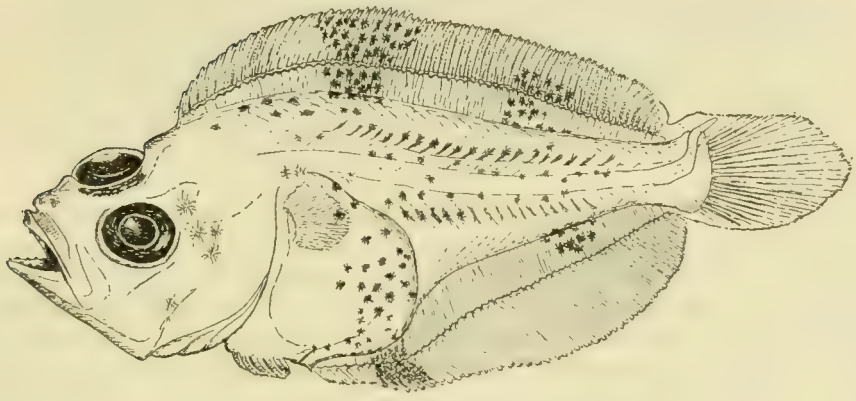

FIG. 270.—Larva, about 8 millimeters

SAND FLOUNDER (*Lophopsetta maculata*)

it wanders any more than do the winter flounder, dab, or witch, when adult, it is perhaps the most stationary of all Gulf of Maine flounders.

Effect of temperature.—Occuring over so wide a range of latitude, and in shallow water exposed to the extremes of winter chilling and summer warming, the adult sand flounder necessarily exists in the widest range of temperature. In winter its native bays are close to the freezing point in the northern part of its range, and probably the entire stock in the Gulf of Maine winters in water colder than 36°, while these same fish summer in temperatures of 50° to 70°, according to exact

locality. Nevertheless temperature is probably the factor that governs the range and local abundance of the species, it being only where the surface temperature rises to 55° or higher in summer, as is the case in Massachusetts Bay, Casco Bay, Minas Channel, and over the southern shallows of the Gulf of St. Lawrence, that it is able to maintain itself in any numbers. This is because its eggs and perhaps its young larvæ can not develop in lower temperatures. These few centers of reproduction are not sufficiently productive to stock the intervening stretches of shore line in the case of so stationary a fish, and for this reason the distribution of this flounder is somewhat analagous to that of the oyster.

Breeding habits.—Ripe fish are taken at Woods Hole in May and June, and as Welsh found the sand flounder spawning late in June at Gloucester no doubt it is a late spring and summer spawner in the Gulf of Maine. The evidence of these Gloucester specimens proves that it breeds in the Massachusetts Bay region, while its local abundance suggests the same for Casco Bay, as does the capture of its larvæ for Minas Channel. It may also breed to some extent at the heads of the warmer and shoaler bays between Casco Bay and Grand Manan, but probably it does not do so in any of the estuaries on the New Brunswick side of the Bay of Fundy for no larvæ have ever been found in Passamaquoddy Bay, a fairly representative situation.

Although it is not yet possible to lay down the extremes of temperature within which this flounder can spawn, it is certain that its eggs develop only in rather warm water, 50° to 60° having been found favorable for hatching at Woods Hole and Gloucester, with even 70° not too high for successful incubation. Thus no part of the Gulf of Maine is too warm for it, but the outer coastal waters east of Penobscot Bay as a whole and most of the Bay of Fundy are probably too cold for successful reproduction.

Being so closely confined to the immediate neighborhood of the coast and to the shoal water, the spawning of the sand flounder necessarily takes place in water of low salinity, with about 32 to 32.5 per mille as the maximum in the Gulf of Maine. The eggs are spherical, transparent, buoyant, and 1 to 1.08 mm. in diameter (measurements taken at Gloucester by Welsh), with a single colorless or pale lemon oil globule of 0.15 to 0.18 mm., and with the surface of the egg showing faint irregular markings. Incubation occupies about eight days at 51° to 56°. Its duration has not been recorded for higher temperatures. The larval stages have not been described, though plentiful at Woods Hole, but the sand flounder, like the winter flounder, completes its metamorphosis while smaller than dab (p. 500) or witch (p. 516), for not only are the vertical fin rays complete and the ventrals formed in specimen only 8½ mm. (fig. 270), but the right eye had already moved to the back line of the head, and at 10 mm. the migration of the eye is completed and the fry are ready to take to bottom.[93]

Commercial importance.—Although this fish is as good on the table as any other flounder so far as flavor goes, it is so small and so thin-bodied that it is never likely to be in demand.

[93] Williams. Bulletin, Museum of Comparative Zoology at Harvard College, Vol. XL, 1902–1903, p. 2.

176. **Gulf Stream flounder** (*Citharichthys arctifrons* Goode)[94]

Jordan and Evermann, 1896–1900, p. 2683.

Description.—This little fish is left-handed (eyes on the left side and guts at the left) with a moderately wide mouth gaping back as far as the forward edge of the eye, a nearly straight lateral line, and with both pectoral fins well-developed, though the one on the eyed side is considerably larger than its mate on the blind side. The left ventral fin is on the midline, the right fin a short distance above it on the side, and while these two fins are alike in females, in males the one on the blind side is much the longer of the pair. The body is ovate in outline and very thin. The long fins are of moderate breadth, with the dorsal fin (about 83 rays) originating over the forward margin of the eye and the caudal fin rounded. The scales are so large that there are only about 40 rows of them along the lateral line.

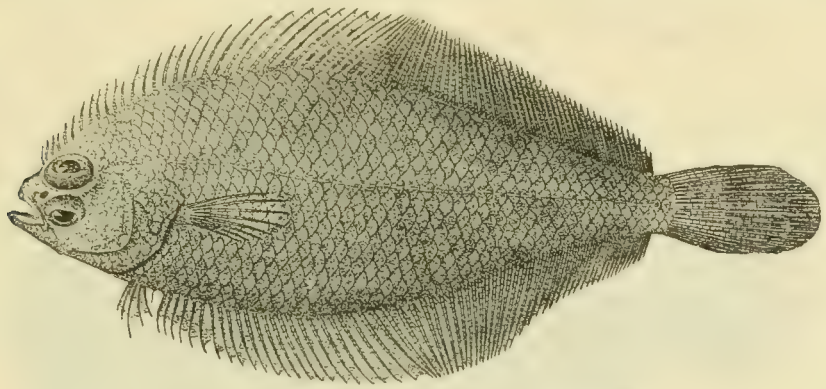

FIG. 271.—Gulf Stream flounder (*Citharichthys arctifrons*)

This species parallels the summer, four-spotted, and sand flounders (the latter its closest Gulf of Maine ally) in its left-handedness, but it is distinguishable from all of these by the fact that its lateral line is almost straight and likewise by the great disparity in size between the two pectoral fins and by its very large scales. Its narrow form and the fact that none of its dorsal fin rays are branched are further points of distinction between it and the sand flounder, and it is much smaller at maturity than any of the flatfishes common within the Gulf.

Size.—Ripe females 3½ to 4 inches in length have been recorded, suggesting that this is about the maximum size.

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[94] A second species of this genus (*C. unicornis*) may be expected on the outer slope of Georges Bank in depths of 100 fathoms and more, since it has been taken off Marthas Vineyard in 115 to 150 fathoms. It is separable from *C. arctifrons* by the fact that there is a short spine on the eyed side of the head above the upper lip (the head of *arctifrons* is spineless). Further points of distinction are that *unicornis* has smaller and more numerous scales (about 60 rows along the lateral line), fewer fin rays (only about 74 dorsal rays), and that its body is "broader" (actually higher).

We have towed the pelagic larvæ of still a third small deep-water flounder (*Monolene sessilicauda*) off the seaward slope of Georges Bank (Bulletin, Museum of Comparative Zoology at Harvard College, Vol. LXI, No. 8, 1917, p. 277), and it has been trawled in depths of 100 fathoms and more off Marthas Vineyard and thence westward and southward along the continental slope. It is left-handed like the summer, four-spotted, and sand flounders, with arched lateral line, but it has no pectoral fin on the blind side. For a detailed description of it see Goode and Bean (1896, p. 452).

Color.—Light brown.

General range.—Outer part of the continental shelf and upper part of the continental slope off eastern North America in depths of 56 to 179 fathoms.

Occurrence in the Gulf of Maine.—Several specimens have been trawled on the slope off Nantucket Shoals in 53 to 134 fathoms, and on February 22, 1920,[95] the *Albatross* took one in a tow net over the southeastern part of Georges Bank from about 82 fathoms (150 meters).

Habits.—Nothing is known of the habits of this little flatfish except that it is restricted to deep water and that ripe females have been found in September Goode and Bean (1896, p. 442) give a list of the records of capture.

177. **Hogchoker** (*Achirus fasciatus* Lacépède)

AMERICAN SOLE

Jordan and Evermann, 1896–1900, p. 2700.

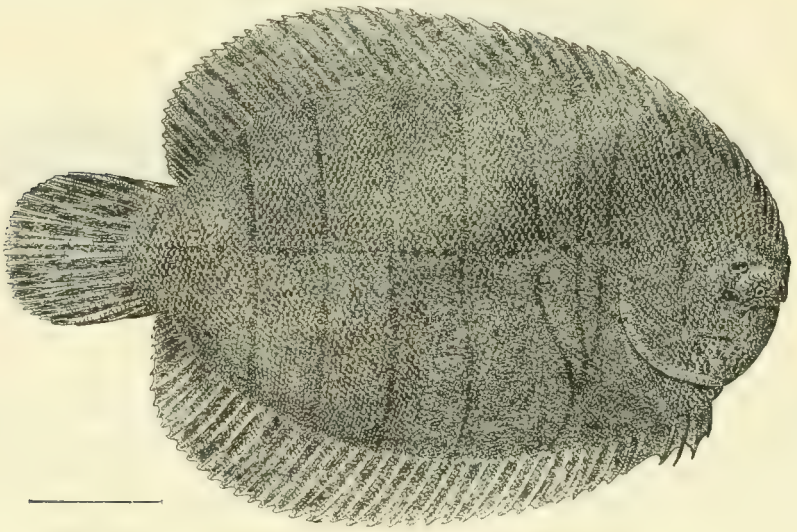

FIG. 272.—Hogchoker (*Achirus fasciatus*)

Description.—This fish is the closest relative of the famous European sole in northeastern American waters. It is right-handed and small-mouthed and can be told at a glance from all other Gulf of Maine flatfishes by the fact that it has no pectoral fin on either side. Its mouth gapes horizontally (that is, along the general fore-and-aft line as this fish lies) with the upper jaw projecting beyond the lower, whereas in all other local flounders the gape is oblique and it is the lower jaw that projects. Furthermore the rounded outline of the head and the lack of a definite snout gives it an aspect very different from that of any other Gulf of Maine flatfish. Equally diagnostic among right-handed species is the fact that the right ventral fin is continuous with the anal, that its long fins are highest toward their rear ends, that

[95] Station 20045.

the dorsal originates at the very tip of the nose (that is, further forward than in our commoner flounders), and that its small eyes are set flat instead of in prominent orbits. Other characters worth mentioning are that the gape of the mouth is shorter and much more crooked on the blind side than on the eyed side (an asymmetry that has been emphasized in most descriptions of this species), that it is evenly oval in outline without a definite caudal peduncle, and that there are about 55 dorsal rays and 38 to 41 anal rays but no pre-anal spine. The scales are very rough on both sides, those of the upper part of the head and chin on the eyed side and on the whole head on the blind side being larger than the body scales. It is very slimy with mucus.

Color.—Described (we have no color notes from life) as varying from dusky or slaty olive to dark brown on the eyed side, barred transversely with a varying number of indistinct darker stripes, and with a dark longitudinal stripe along the lateral line. The dorsal, caudal, and anal fins are of the general body tint, variously dark clouded. The blind side is dirty white, usually marked (in northern fish) with dark round spots which vary in size and number, but northern specimens, like southern ones, occasionally lack these spots.

Size.—Six to seven inches is about the maximum length.

General range.—Atlantic and Gulf coasts of the United States, with Massachusetts Bay as the northern limit. The hogchoker is abundant south of Chesapeake Bay and moderately common as far north as southern New England but decidedly rare north of Cape Cod.

Occurrence in the Gulf of Maine.—This little flatfish has been reported from Provincetown (where Captain Atwood spoke of it as plentiful); from Boston Harbor, whence the Museum of Comparative Zoology possesses several, all caught long ago; from the mouth of the Charles River (2 specimens reported in 1847); and from Nahant (one taken in 1840); but it is more than half a century since it has been brought to scientific attention north of Cape Cod, and if caught from time to time, as has probably been the case, it has not been recognized. It is not known north or east of Cape Ann nor on the offshore banks.

Habits and food.—Little is known of the habits of this species except that it is a fish of shoal and brackish waters, most often found in river mouths and on the flats in bays or estuaries, sometimes running up into fresh water. It breeds in spring, for fish that were apparently ripe have been taken at Woods Hole in May, but its life history has not been followed nor is its diet known. Probably it is normally carnivorous like other American flatfishes, although fragments of seaweed have been found in its stomach.

Commercial importance.—The hogchoker is so small that it is of no commercial value, although said to be delicious eating.

THE ANGLERS. FAMILY LOPHIIDÆ

This family is the only Gulf of Maine representative of the small but anatomically remarkable tribe of pediculate fishes in which the base of the pectoral fin takes the form of an arm (pseudobrachium) formed by the elongation of the carpal bones (actinosts), which are so short in all other bony fishes that they are not noticeable externally. Coupled with this peculiar structure of the pectorals, the gill openings are reduced to small apertures in or near the axils ("armpits") of these fins. The anglers are characterized among their immediate relatives by a very large and very much flattened head, enormous mouth, and the fact that there are but two bones in each "arm." One species is common in the Gulf of Maine.[96]

178. **Goosefish** (*Lophius piscatorius* Linnæus)

MONKFISH; ANGLER; BELLOWSFISH; ALLMOUTH; MOLLIGUT; FISHINGFROG

Jordan and Evermann, 1896–1900, p. 2713.

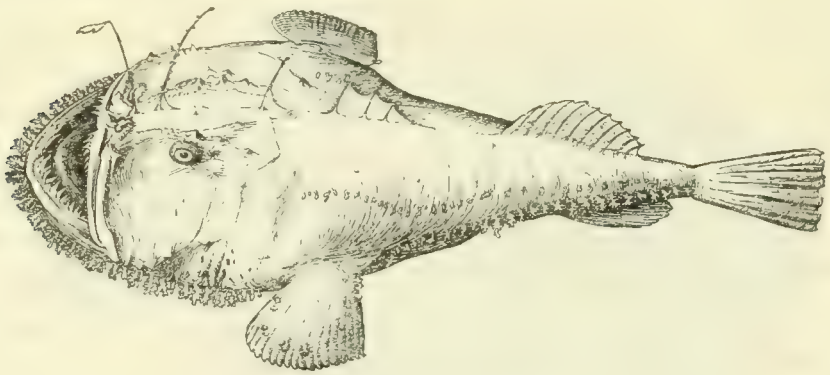

FIG. 273.—Angler (*Lophius piscatorius*)

Description.—The goosefish is so unlike any other Gulf of Maine fish that, once seen, there is no danger of mistaking it. It is so much compressed, dorsoventrally, and so soft in texture that when left stranded on the shore it flattens down until hardly thicker than a skate. As seen from above its head is rounded, disklike, about as broad as long, and enormous in comparison with its body, which is so narrow and tapering back of the pectorals as to give the fish a tadpolelike appearance. Its most noticeable character is its enormous mouth, which is directed upward, with its lower jaw projecting so far beyond the upper that most of the lower teeth are freely exposed even when the mouth is closed. Both jaws are armed with long, slender, curved teeth, all alike in form but of various sizes and very sharp. In a large fish some of them may be as much as an inch long. The teeth in the lower jaw are in 1 to 3 rows, mostly large, while in the upper jaw the few in the middle (there is a toothless space in the midline) are largest, with a single row of smaller ones flanking them; and there are likewise several rows

[96] Several other pediculate fishes have been trawled on the continental slope off New England, as described by Goode and Bean (1896), none of them, however, within the geographic limits to which this report is confined.

of thornlike teeth on the roof of the mouth, while all the teeth point inward toward the gullet. The gill openings are behind the pectoral fins and lack the gill covers to be seen in most bony fishes. The eyes are situated on the top of the head and are directed upward.

The pectoral fins are exceedingly diagnostic, for instead of rising directly from the sides of the body, as in most bony fishes, their bases take the form of thick fleshy arms as already described (p. 524), bearing the fins proper at their outer edges, while the latter are so thick skinned that their rays are hardly visible except in the scalloping of the margins. They are fanlike when spread. There are three stiff slender spines (representing the anterior part of the spiny dorsal fin) hardly thicker than bristles on the top of the head, the first being close behind the tip of the snout, the second slightly in front of the eyes, and the third on the nape; and while the first and second are movable from recumbent to erect, the third slopes backward with its basal half imbedded in the skin.[97] The relative lengths of these spines vary, but in most of the fish we have seen the first two have been about equal in length or the second slightly the longer, with the third much the shortest of the three. The first bears an irregular leaflike flap of skin at its tip, supposed to play an important rôle in the daily life of the goosefish as a lure for its prey (p. 528), while the second and third spines have small triangular membranes at their bases and one or both may be fringed with short lobes of skin. There are two well-developed dorsal fins, the first (of three spines) situated over the pectorals and the second (10 to 11 rays) on the rear part of the trunk. The single anal fin (9 to 10 rays) stands below the second dorsal, and the ventrals (about 5 thick rays) are situated under the head well in front of the pectorals. The caudal fin is small and broom shaped. The dorsal fins have thin delicate membranes but the caudal, anal, and ventrals are thick and fleshy. The skin is scaleless, very smooth and slippery to the touch, and there is a row of fleshy flaps of irregular shape running around the margin of the head and the edge of the lower jaw, with smaller tags fringing the sides of the trunk as far back as the base of the caudal fin. Furthermore, the upper side of the head bears several low conical spines which vary in prominence from fish to fish.

Color.—The many goosefish we have seen (and this corroborates the published accounts) have been chocolate brown above, variously and very finely mottled with pale and dark. The dorsal fins, the upper sides of the pectorals, and the caudal fin are of a darker shade of the same color as the back, nearly black at the tips, while the whole lower surface of the fish is dirty white. Sometimes, it is said, the upper side is dotted with white spots, but we have seen none so marked. Very small ones are described as mottled and speckled with green and brown.

Size.—Adults run from 3 to 4 feet long,[98] weighing up to 45 pounds, and they have been recorded as heavy as 70 pounds. One 38 inches long, captured at Woods Hole on July 25, 1923, weighed 32 pounds alive.

[97] Sometimes not more than one-third is imbedded.

[98] Rumor has it that goosefish grow to 6 feet, but we find none definitely recorded (and have seen none) longer than 4 feet.

General range.—The extreme range of the goosefish on the coast of eastern North America is from the Newfoundland Banks and Gulf of St. Lawrence to North Carolina[99] in shoal water, and as far south as the Barbadoes in deep water, if these southern specimens[1] actually belong to the same species. It is equally common on the other side of the North Atlantic.

Occurrence in the Gulf of Maine.—This is a familiar fish in the Gulf of Maine both along shore and on the outer fishing banks. It has been recorded in print from the west coast of Nova Scotia (St. Mary Bay) and from various localities in the Bay of Fundy where, according to Huntsman, large ones are frequently taken on line trawls or found stranded on the beach. It is well known, if not abundant, all along the coast of Maine,[2] and we once caught as many as eight (all large) in Ipswich Bay in one haul of a beam trawl only 8 feet across the mouth. In Massachusetts Bay goosefish are most common on the smooth bottom south of Boston, and they are so numerous in Cape Cod Bay that one can hardly walk the beach for an afternoon without finding a jawbone bleaching on the sand, which applies equally all along the outer shores of Cape Cod where they often strand. Fishermen also speak of them as common on and about Stellwagen Bank, while goosefish formed about 1 per cent (in numbers of individuals) of the catches of certain otter trawlers in the South Channel and on Georges Bank in 1913. They are also reported to be equally plentiful on Browns Bank.

The depth zone occupied by this fish in the inner parts of the Gulf of Maine extends from just below tide mark down to at least 50 or 60 fathoms. We can not say whether they inhabit the very soft bottoms of the deeper basin, but there is nothing in the depth of the latter to prevent them, for goosefish have been trawled down to 365 fathoms on the continental slope off southern New England and down to at least 100 fathoms off the outer coast of Nova Scotia.

Food.—The most interesting phase in the life of the goosefish is its insatiable appetite. Its larvæ, like most young fish, feed on various small pelagic animals, copepods, crustacean larvæ, and especially on Sagittæ; and since Sagittæ are the chief diet of young goosefish in the Adriatic during the life of the latter near the surface very likely they serve the same purpose in the Gulf of Maine.

After the goosefish takes to the bottom it becomes, in the main, a fisheater, and the following Gulf of Maine species have been recorded from its stomach: Spiny dogfish, skates of various kinds, eels, launce, herring, alewives, menhaden, smelts, mackerel, weakfish, cunners, tautog, sea bass, butterfish, puffers, various sculpins, sea ravens, sea snails, silver hake, tomcod, cod, haddock, hake, witches, plaice, dab, winter flounders, and various other species of flatfish unnamed, as well as its own kind.[3] As one of its vernacular names implies, goosefish often capture seabirds—cormorants, herring gulls, widgeons, scoters, loons, guillemots, and

[99] Smith (Fishes of North Carolina, North Carolina Geological and Economic Survey, Vol. II, 1907) describes it as being very common at Cape Lookout, and we have seen many stranded on the beach in Pamlico Sound, a few miles north of Cape Hatteras, in winter.

[1] Goode and Bean, 1896, p. 486.

[2] Reported from Eastport, from the outer part of Penobscot Bay, from sundry localities in Casco Bay, and off Saco Bay, while the *Grampus* trawled it off Monhegan Island and off Casco Bay, and I have known goosefish to come ashore on Mount Desert Island.

[3] Also sundry European species not necessary to mention here.

razor-billed auks all being on its recorded dietary, while I have found grebes and other diving fowl, such as scaup ducks and mergansers, in goosefish in Pamlico Sound, N. C. It is questionable, however, whether even the largest would be able to master a live goose, as rumor has it, nor do the local fishermen believe it ever does so in Pamlico Sound, though the abundance of wild geese there in winter would afford it every opportunity. Goode (et al., 1884), however, tells of one which he actually saw struggling with a loon.

Goosefish are also known to devour invertebrates such as lobsters, crabs of several species, hermit crabs, squids, annelid worms, shellfish, starfish, sand dollars, and even eelgrass—in short, nothing edible that strays within reach comes amiss—and examinations of stomachs have shown (as might have been expected) that the relative importance of various articles in its diet varies widely on different grounds, depending on what is available. Near Woods Hole, for instance, Field (1907, p. 39) found skates, flounders, and squid its chief dependence. The 32-pounder from Woods Hole mentioned above contained 2 menhaden, 1 spiny dogfish a foot long, and the vertebral columns of 6 others. In Scottish waters [4] it feeds chiefly on dabs, haddock, launce, and the European whiting; off Norway it feeds on herring, with skates, gurnards, and other bottom fish; on hake [5] in eastern Canadian waters, including the Bay of Fundy; and on haddock, flatfish, and skates on Georges Bank. Crabs are the chief invertebrate contribution to its diet.

The goosefish is as remarkable for its appetite as for the variety of animals that fall prey to it. We read, for instance, of one that had made a meal of 21 flounders and 1 dogfish, all of marketable size; of half a pailful of cunners, tomcod, and sea bass in another; of 75 herring in a third; 3 flatfish, 1 dogfish, 1 European whiting, 3 crabs, and 14 starfish in another; and of one that had taken 7 wild ducks at one meal. In fact it is nothing unusual for one to contain at one time a mass of food half as heavy as the fish itself, and with its enormous mouth (one 3½ feet long gapes about 9 inches horizontally and 8 inches vertically) and capacious belly it is able to swallow fish of almost its own size. Fulton, for instance, found a codling (a European species) 23 inches long in a goosefish of only 26 inches, while Field took from another a winter flounder almost as big as its captor. Captain Atwood long ago described seeing one struggling to swallow another as large as itself, and examples of this sort could be multiplied. As a rule, however, goosefish feed on small fish, not on large ones, and even the largest of them take very small fry on occasion. Interesting, because exceptional, is Linton's [6] report of one full of mud containing small shellfish, crustaceans, and worms. Goosefish, like most fish of prey, often swallow indigestible objects. They have even been credited (on how good evidence we can not say) with pouching lobster-pot buoys, and the story of one whose mouth made a holding ground for the boat anchor of an angler from Nahant has often been related.

[4] Fulton (Twenty-first Annual Report, Fisheries Board for Scotland, 1902 (1903), Part III, p. 195) describes the stomach contents of 541 goosefish from various localities off Scotland.

[5] Connolly, 1920, p. 16.

[6] Bulletin, United States Fish Commission, Vol. XIX, 1899 (1901), p. 487.

In Scottish waters, where the habits of this species are better known than in the Gulf of Maine, its local abundance depends on the supply of small fish, and in spite of their poor ability as swimmers goosefish have been found to congregate near particular shoals of herring. W. F. Clapp, who has often watched the feeding habits of goosefish at low tide in Duxbury Bay, Mass., where they are very plentiful, describes them to us as lying perfectly motionless among the eelgrass with the tag or "bait" on the tip of the first dorsal ray swaying to and fro over the mouth, either with the current or by some voluntary motion so slight as to be invisible. The only fish he has seen them take are tomcod, and when one of these chances to approach it usually swims close up to the "bait" but never (in his observation) actually touches it, for as soon as the victim is within a few inches the goosefish simply opens its vast mouth and closes it again, engulfing its victim instantaneously. These observations are the more welcome as no other recent student seems to have seen the feeding habits of this species in its natural surroundings, and they show that it depends mostly on such fish or Crustacea as chance to stray close enough to be snapped up from ambush or seized by a sudden rush. However, the fact that it has been known to seize and swallow hooked fish as the latter were being hauled up, and even to capture sea birds sitting on the surface, proves that it may make considerable excursions for a meal on occasion.

Rate of growth.—The few data that have so far been gathered as to the rate of growth of this species are somewhat contradictory. Thus the measurements of Scottish fish tabulated by Fulton seem to us to warrant his schedule of a mean length of about 6½ inches at 6 months, 12½ inches at a year and a half, 18 to 18½ inches at two and one-half years, and his assumption that in Scottish waters a goosefish 3 years old will be about 21 inches long and one 4 years old about 26 or 27 inches in length. Bay of Fundy specimens examined by Connolly (1920) had grown little more than half as fast (if the concentric rings in their vertebræ on which he based his estimates are indeed annual), for fish with 4 rings were only about 18 inches long, those with 9 rings about 31 inches, fish with 10 rings about 37 inches, and those having 12 rings were about 40 inches in length. No attempt has been made to trace the growth of this fish living in other parts of the Gulf of Maine or on Georges Bank.

The smallest ripe males seen by Fulton were 26 to 27 inches long and females were 30 inches, which would mean an age of 4 to 5 years, according to the faster growth schedule and 7 to 8 years by the slower one, while goosefish seldom mature in either side of the North Atlantic when less than about 30 inches long.

Breeding habits.—The spawning season covers a long period. Off the southern coasts of New England goosefish eggs have been taken as early as May (Woods Hole) and as late as August (Newport), but breeding may not commence until early summer north of Cape Cod, for June 24 (Passamaquoddy Bay[7]) is the earliest date on which eggs have been seen north of Cape Cod while August 8 (off Penobscot Bay, *Grampus*, station 10025) and 9 (Bay of Fundy) are the latest dates.

In Scottish waters the breeding season is about a month earlier both in its inception and probably in its completion, judging from the state of sexual maturity

[7] Connolly, 1922, p. 116.

of the fish[8] and the presence of the eggs, while in the Mediterranean, with its higher temperature, the seasonal occurrence of the larvæ points to early winter spawning, though eggs have not actually been found there.[9]

The locality of spawning, whether inshore in shoal water or offshore in deep water, has been the subject of some discussion, Bowman[10] having advanced the second possibility to account for the fact that most of the egg veils so far reported have been far advanced in incubation, and to explain the apparent rarity of larvæ in northern seas.

Both of the Bay of Fundy egg clusters described by Conolly were newly spawned, which is sufficient proof that goosefish do breed in the inner parts of the Gulf of Maine; and they do so commonly, it seems, in the Woods Hole region where the egg skeins are familiar objects both floating and when entangled in the local fish traps. Furthermore large adult fish are present in abundance on their regular grounds throughout the spawning season, which would hardly be the case if they moved offshore or into deep water to breed, nor would any very extended journey seem within the physical ability of so stationary a fish and so feeble a swimmer. We therefore believe the weight of evidence points to the same shoal coastal bottoms, which they inhabit at other times, as their spawning grounds.

The only definite records for monkfish eggs in the Gulf of Maine so far published are those just mentioned, nor is the local list of captures of its larvæ much larger, consisting only of three taken off Brazil Rock (described by Conolly), two very small ones (5 and 6.5 mm.) towed by the *Grampus* in Massachusetts Bay on July 12, 1912, and September 29, 1915, and of others described from the same general region by Agassiz (1882). Since both the eggs and the larvæ are exceedingly conspicuous and easily recognized, while the latter pass through a long pelagic stage, it does not seem likely we would have missed them constantly in our tow nets were they as plentiful as the corresponding stages of other common Gulf of Maine fishes that breed at the same season. The simplest explanation for this apparent rarity of the young would be that while a few breed successfully in the Gulf of Maine the maintenance of the local stock depends more on immigration from elsewhere, with the frequency of egg veils at Woods Hole pointing to southern New England waters as their source; but this suggestion is advanced only as a tentative hypothesis, to be accepted or rejected in the light of later knowledge.

The eggs are shed in remarkable ribbon-shaped veils of mucus, often 20 to 30 feet long by 2 or 3 feet wide, in which they are arranged in a single irregular layer, each egg floating free, oil globule uppermost, in a hexagonal cavity. It is probable that each sheet is the product of a single ovary, and Fulton[11] estimated the number of eggs in two nearly ripe ovaries at 1,345,848 and 1,312,587, respectively. These veils are light violet gray or purplish brown in color, made more or less blackish by the embryonic pigment of the eggs according to the stage of development attained by the latter. They are so conspicuous as they float on the surface that

[8] Fulton. Sixteenth Annual Report, Fishery Board for Scotland, 1897 (1898), Part III, pp. 125–134, Pls. II–III.
[9] Stiasny. Arbeit, Zoologische Institute Vienna, Vol. 19, 1911, p. 14.
[10] Fishery Board for Scotland, Scientific Investigations, 1919 (1920), No. II, pp. 1–42, Pls. I–VI, 2 charts.
[11] Sixteenth Annual Report, Fishery Board for Scotland, 1897 (1898), Part III, pp. 125–134, Pls. II–III.

fishermen of southern New England have long been familiar with them, though it was not until about 1871 that Alexander Agassiz demonstrated their true parentage.[12] The eggs occasionally become isolated, perhaps by some storm shredding the mucous veil to pieces, and when this occurs they float like any ordinary buoyant fish eggs. We have not actually found them in this condition in the Gulf of Maine, though Agassiz and Whitman saw isolated eggs at Newport.

The eggs themselves, large numbers of which have now been examined, are spherical or slightly oval, 2.13 to 2.5 mm. in diameter and averaging about 2.3 mm. as they lie in their mucus cells,[13] but isolated eggs as large as 3.11 mm. and others as small as 1.67 mm. have been reported. The yolk is homogeneous, straw-colored, and with either one large oil globule of 0.4 to 0.56 mm. or several smaller ones.

The duration of incubation is not known. The larvæ[14] are about 4.5 mm. long at hatching and float at first with the yolk uppermost. Within 4 days or so the first dorsal fin ray (which is to form the *second* head spine of the adult) appears as a lobe at the margin of the embryonic finfold on the nape, while at about 7 days, when the larva is 5.5 mm. long, the pectorals are formed and the ventral fins have appeared as two long conical processes below and behind the pectorals (fig. 275).

In summer temperatures the absorption of the yolk and the formation of the mouth are complete and the larva rights itself in the water in about two weeks, while either just before or shortly after the disappearance of the yolk (North American and North Sea specimens differ in this) and at a length of 8 to 10 mm. a second dorsal ray appears behind the first, the ventrals elongate and become two-rayed, and the pigment congregates in three masses behind the vent. From this point on larval goosefish described from different seas have shown considerable differences at different sizes, depending on the rapidity of development as compared with the rate of growth in waters of different temperatures; also in the detailed structure of the fins and in the general outlines and proportions of head to body, but the successive stages have been essentially similar in all. Thus North Sea specimens of about 10 mm. show a third dorsal ray on the nape behind the two previously formed, while the first traces of the rays of the second dorsal fin and of the anal have appeared and the ventrals have lengthened until they reach back past the middle of the trunk and become three-rayed, whereas New England larvæ have shown a fourth dorsal ray before the third ventral appears (fig. 276). A fifth dorsal ray next appears behind those preexisting, and a sixth in front of them, all being connected with the membrane at their bases but free at the tips. The pectorals assume a great breadth and fanlike outline, the second dorsal, the anal, and the caudal fins take definite form, the ventral rays become filamentous at their tips, streaming far behind the tail, and a complete row of teeth appears in the lower jaw, with a few in the upper. The goosefish pictured in this

[12] Baird. American Naturalist, Vol. V, 1871, pp. 785–786.

[13] Agassiz and Whitman (1885) give the diameter as only 1.75 mm., but this may have been after preservation as Connolly's eggs of 1.7 mm. were.

[14] Larval goosefish from New England have been described by Agassiz (1882, p. 280) and by Agassiz and Whitman (1885). Specimens from the North Sea have been described by Bowman (Fishery Board for Scotland, Scientific Investigations, 1919 (1920), No. II, pp. 1–42, Pls. I–VI, 2 charts), while a Nova Scotian example was described by Connolly (1922), and others from the Adriatic by Stiasny (Arbeit, Zoologische Institute Vienna, vol. 19, 1911, p. 71).

stage by Agassiz (fig. 277) was 30 mm. long, and one much like it taken off Brazil Rock and described by Connolly was 27 mm. in length, but according to Stiasny this state is attained in the Mediterranean by larvæ only 13 to 18 mm. long. In later stages described by him from the Adriatic the foremost dorsal ray becomes

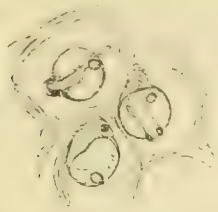

FIG. 274.—Egg. After Agassiz

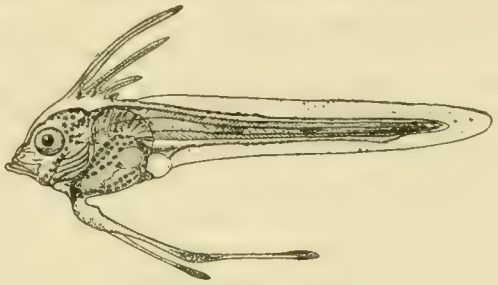

FIG. 276.—Older larva. After Agassiz

FIG. 275.—Newly hatched larva. After Agassiz

FIG. 277.—Larva, 30 millimeters. After Agassiz

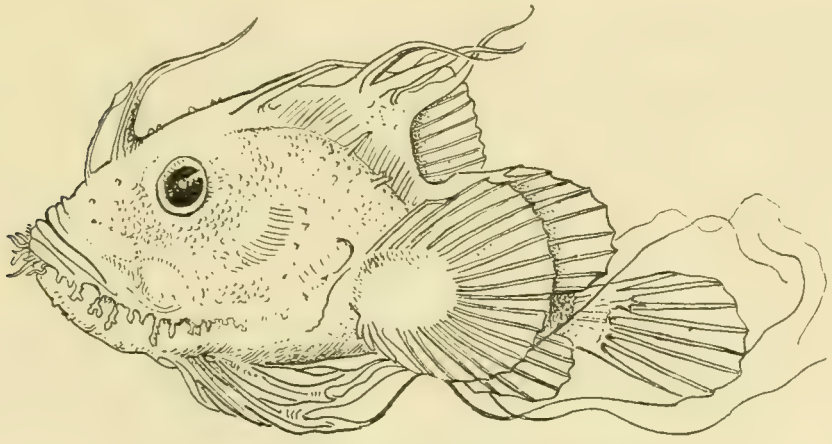

FIG. 278.—Larva (Mediterranean), 50 millimeters. After Stiasny

ANGLER (*Lophius piscatorius*)

bristlelike and the flap appears at its tip, the last three of the free rays on the nape join together as the future first dorsal fin, lappets of skin appear around the margin of the lower jaw and along the cheeks, the head broadens and becomes depressed, and the lower jaw projects further, while the young fish are still pelagic with enormous pectoral fins and threadlike ventrals (fig. 278).

The largest free-swimming larva seen by Stiasny was 50 mm. long. Probably the young take to the ground shortly after this stage, for Bowman[15] describes fry of 65 mm., trawled on the bottom, as of adult form in most respects except that the pectorals were proportionately larger. To attain this state entails a growth on the part of the head out of proportion to the rest of the body, enlargement of the mouth, shrinkage of all fins (of the ventrals most of all), alteration of the second and third free dorsal rays into spines (they are soft previously), and a general flattening of the whole fish. Young of 3 inches taken at Halifax and one of 4½ inches from Campobello (both pictured by Connolly) were at about this same stage in development, but none intermediate between these and fish fully adult in form and upwards of 8 to 10 inches long seem to have been reported from the Gulf.

Commercial importance.—Goosefish are taken chiefly by otter trawls and line trawls but occasionally on hand lines and in traps and pound nets. Up to the present time no regular commercial use has been made of the goosefish in America, but in spite of the hideous appearance of its head (which should, of course, be cut off and thrown away) it is an excellent food fish, white-meated, free of bones, and of pleasant flavor, as Doctor Connolly assures us from personal experience. It is regularly marketed in northern Europe. English and Scotch vessels, for example, landed nearly 3,000,000 pounds from the North Sea in 1904, valued in England at about 1½ cents per pound, as compared with about 2½ cents for cod.

[15] Fishery Board for Scotland, Scientific Investigations, 1919 (1920), No. II, pp. 1–42, Pls. I–VI, 2 charts.

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ADDENDA

MACKEREL SHARK (*Isurus punctatus* Storer), p. 36, and PORBEAGLE (*Isurus nasus* Bonaterre), p. 36

The *Halcyon* recently caught, on Platts Bank, a mackerel shark indistinguishable from *Isurus punctatus* except that its teeth were denticulate like those of the European *I. nasus* instead of smooth, as Garman (1913) describes and figures them for *I. punctatus*. In the face of this capture, it is no longer possible to maintain a North American smooth-toothed species as contrasted with a north European with denticulate teeth (p. 36). Either the two intergrade, in which case the common mackerel shark of our waters must be known as *I. nasus*, or, if they are actually distinct, both of them occur in the Gulf of Maine. W. C. Schroeder is now engaged on a revision of the mackerel sharks of this genus, but for the time being the question must be left open.

SPINY DOGFISH (*Squalus acanthias* Linnæus), p. 44

Jensen ("The Selachians of Greenland," in Mindeskrift for Jepetus Steenstrup, 1914, p. 7) lists several definite records of this species from west Greenland, where, however, it appears only as a stray from the south. We find no record of it on the American coast north of the Straits of Belle Isle.

BLACK DOGFISH (*Centroscyllium fabricii* Reinhardt), p. 52

Jensen ("The Selachians of Greenland," in Mindeskrift for Jepetus Steenstrup, 1914, p. 4) lists several specimens from Davis Straits and from west Greenland, where it seems rather common. He also reports cephalopods, crustaceans, and Medusæ from their stomachs, and remarks that the shark is viviparous, having been taken gravid in February with embryos 124 millimeters long.

GREENLAND SHARK (*Somniosus microcephalus* Bloch and Schneider), p. 53

Jensen ("The Selachians of Greenland," in Mindeskrift for Jepetus Steenstrup, 1914, p. 8) gives an interesting account of the habits of this shark in west Greenland waters, and of the local shark fishery.

SHAD (*Alosa sapidissima* Wilson), p. 113

Dr. A. H. Leim's report on his studies on the shad of the Bay of Fundy, carried out under the auspices of the Biological Board of Canada (Contributions to Canadian Biology, new series, 1924, vol. 2, part 1, pp. 163–184) contains much important information on the life history of the species. Received too late for discussion in

our account of the shad (p. 113), we give here a brief summary of his more important conclusions, based partly on observational and partly on experimental data.

Spawning in the Shubenacadie River takes place chiefly in temperatures higher than 12° C. (53.6° F.), and is temporarily interrupted if the temperature falls lower. At 11 to 15° C. hatching takes place in 8 to 12 days, with the yolk sac absorbed in 4 to 7 days. Normal development of the eggs did not take place in water colder than 7°.

Leim's most interesting discovery is that larval development is more successful in slightly saline water than in fresh, with about 7.5 per mille as the optimum salinity. Notes are also given on the rate of growth of the larvæ, and on their food, as well as of the food of the maturing shad in the Bay of Fundy, which consisted chiefly of copepods and mysid shrimps.

Scale studies indicated a length of 10 to 14 centimeters at the end of the first growing season, and of 20 to 25 centimeters at the end of the second, with the fish maturing from four years of age on.

Leim believes that the shad of the rivers tributary to the Bay of Fundy remain for the most part within the latter while in salt water.

Genus Myctophum, p. 149

Goode and Bean's (1896, p. 511) report of the capture of *Myctophum affine* Lütken (as *M. opalinum*) over the southeast slope of Browns Bank (lat. 42° 20′ N., long. 65° 07′ W.) at 104 fathoms brings this genus within the geographic limits of the Gulf of Maine.

Myctophum resembles its near relative, the lanternfish (p. 149), in its general appearance, having one short, soft-rayed dorsal fin, an adipose fin behind the latter, a forked tail fin, the anal fin mostly or wholly behind the dorsal, large eyes, a wide, very oblique mouth gaping back at least as far as the hinder margin of the eye, and numerous phosphorescent organs on the sides. The longer snout and smaller mouth of Myctophum, with the fact that the luminous organs on the snout are in the form of small dots instead of a large patch covering the entire tip of the snout, distinguish Myctophum from Æthoprora (p. 149).

Many species of Myctophum have been described, all of small size, most of them (perhaps all) dark colored and all living pelagic in the mid-depths of the oceanic basins, where they are among the commonest of fishes, chiefly below 150 fathoms.

The arrangement of the phosphorescent organs or spots affords the most useful distinction within the genus, under which Brauer (Die Tiefsee-Fische. Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition, 1898–99 (1906), Band XV, Teil I, p. 150) lists 20 odd from the North Atlantic north of 10° N. lat., any one of which might stray within the 150-meter contour abreast the Gulf of Maine. However, only one has actually been taken within the limits of the gulf (noted above), though others have been taken further out over the continental slope, and since none of them has any real place in the Gulf of Maine fauna it seems needless to burden this report with descriptions of them. Should one be picked up, we refer its captor to Brauer (loc. cit.), or suggest that the specimens be submitted to the United States Bureau of Fisheries for identification.

Sand launce (*Ammodytes americanus* DeKay), p. 183

During December, January, and February of 1924–1925 the *Fish Hawk* towed numbers of larval launce (identified by Mrs. C. J. Fish and R. A. Goflin of the Bureau of Fisheries) near Provincetown and in Cape Cod Bay, evidence both that this general region (when adults are abundant) is the site of considerable reproduction and that spawning commences as early as November in this part of the Gulf of Maine.

Swordfish (*Xiphias gladius* Linnæus), p. 221

A swordfish caught in the summer of 1921 by Capt. Irving King and landed at the Boston Fish Pier weighed 915 pounds dressed—hence upwards of 1,000 pounds alive (Fishing Gazette for September, 1921, p. 13). This is the heaviest swordfish definitely recorded from the Gulf of Maine. The specimen was not measured, but the sword being more than 5 feet, the total length of the fish must have approximated 15 feet.

Pilotfish (*Naucrates ductor* Linnæus), p. 229

We saw a pilotfish about a foot long, freshly taken from a mackerel net, in Provincetown Harbor, August, 1924, this being the third definite record for this species in the Gulf of Maine.

Tautog (*Tautoga onitis* Linnæus), p. 286

In August, 1924, we saw a number of small tautog seined on the sand beaches around Provincetown Harbor, proving that they frequent sand bottom to some extent north as well as south of Cape Cod.

Bluemouth (*Helicolenus dactylopterus*, De la Roche)

This scorpænid, common in deep water in the Mediterranean, off Portugal, and off Norway, has been reported by Goode and Bean (1896, p. 523) at four stations along the continental edge abreast the Gulf of Maine and off southern New England, between longitudes 69° 42′ and 71° 02′ W., in depths of 156 to 202 fathoms.

It is very closely allied to *Helicolenus maderensis* (p. 313), which it so closely resembles in general appearance, arrangement and forms of the fins, and in color, that the description given above (p. 313) would apply equally to the bluemouth. The cheek spines of the latter and the spines on the top of the head, however, are described as much less prominent. Furthermore, according to available accounts and illustrations (we have not seen either species), the black-bellied rosefish (*Helicolenus maderensis*) has two conspicuous spines upon the upper part of the opercular flap, which are either very small or lacking in the bluemouth (*H. dactylopterus*).

In Goode and Bean's illustration (1896, fig. 244) and Jordan and Evermann's account (1896–1900, p. 1837) of the bluemouth, the tip of the pectoral fin reaches as far back as the origin of the anal, but as it falls considerably short of it in Scandinavian specimens (Smitt, Scandinavian fishes, p. 154, fig. 43), Smitt doubts

whether the American form is actually identical with the European, a question on which we have nothing to contribute.

Rock eel (*Pholis gunnellus* Linnæus), p. 359

The following observations, communicated by W. C. Schroeder, prove that the rock eel descends deeper in the Gulf of Maine than we had supposed (p. 361): Twelve miles southeast of Round Shoal buoy, Nantucket Shoals; several specimens found in the stomachs of cod in 15 fathoms; also one, eaten alive, from the mouth of a pollock caught at 34 fathoms on Platts Bank, July 28, 1924.

American pollock (*Pollachius virens* Linnæus), p. 396

The following measurements by W. C. Schroeder show that under favorable conditions pollock may be considerably heavier at corresponding lengths than those listed on page 397:

Fish caught on Rose and Crown Shoals off Nantucket, August 16, 1923.

Length, inches	Weight, pounds
27¾	9
29½	11½
35	21
41¼	35½

Capture by the *Fish Hawk* of considerable numbers of larval pollock in the tow net during December and January, 1924–25, off the western and southern sides of Stellwagen Bank proves that this important spawning ground is a favorable nursery for the young fish (p. 405).

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